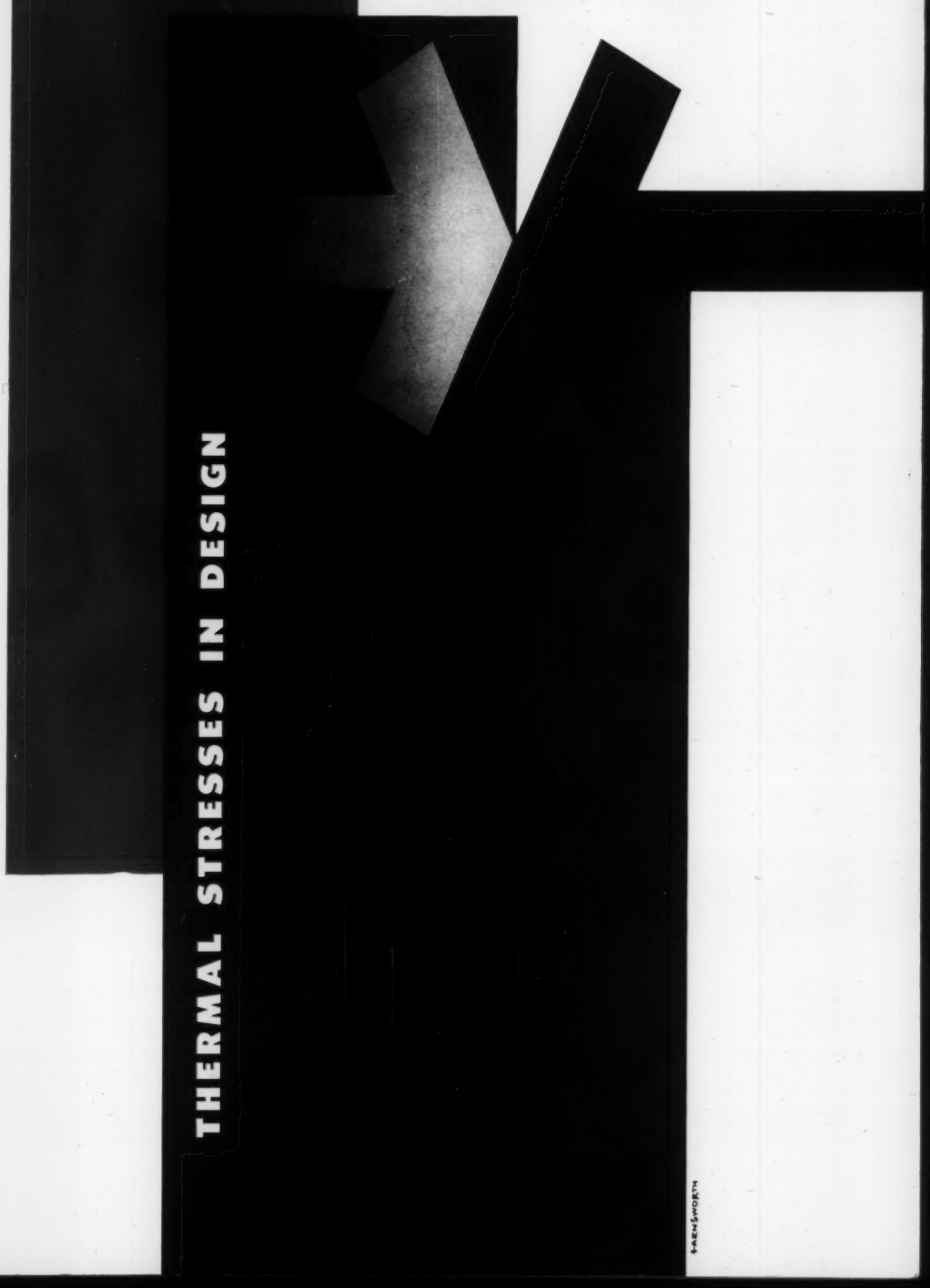
JUNE 12, 1958

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY

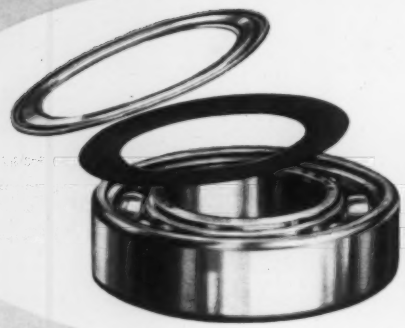


THERMAL STRESSES IN DESIGN

NORMA-HOFFMANN

"Plastiseal"

BALL BEARINGS



ASSURE YOU OF *Maximum Sealing with Minimum Friction*

Norma-Hoffmann "*Plastiseal*" Ball Bearings keep out damaging dirt and retain full lubrication. That's because they're made with oil and grease resistant synthetic rubber seals, firmly attached to the outer ring, with very light rubbing contact on the inner ring's smooth recess.

Other Norma-Hoffmann "Plastiseal" advantages include:

- Low seal friction insuring low wattage and freedom from wear.
- Compact design for completely sealed bearings.
- Prepacking with metered quantity of wide temperature range grease.

For complete details on Norma-Hoffmann's "*Plastiseal*" Ball Bearings, write now for catalog.

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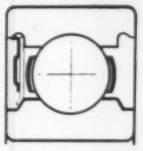
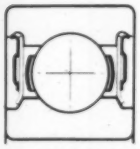
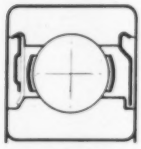


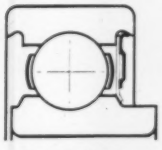
"K" Series
with Single Rubber Seal



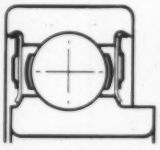
"KK" Series
with Double Rubber Seal



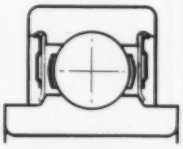
"KP" Series
with Single Rubber Seal and Metal Shield



"8000-K" Series
with Single Seal and Extended Inner Ring



"8000-KK" Series
with Double Seal and Extended Inner Ring



"88000-KK" Series
with Double Seal and wide Inner Ring

Circle 401 on Page 19

precision ball, roller & thrust bearings

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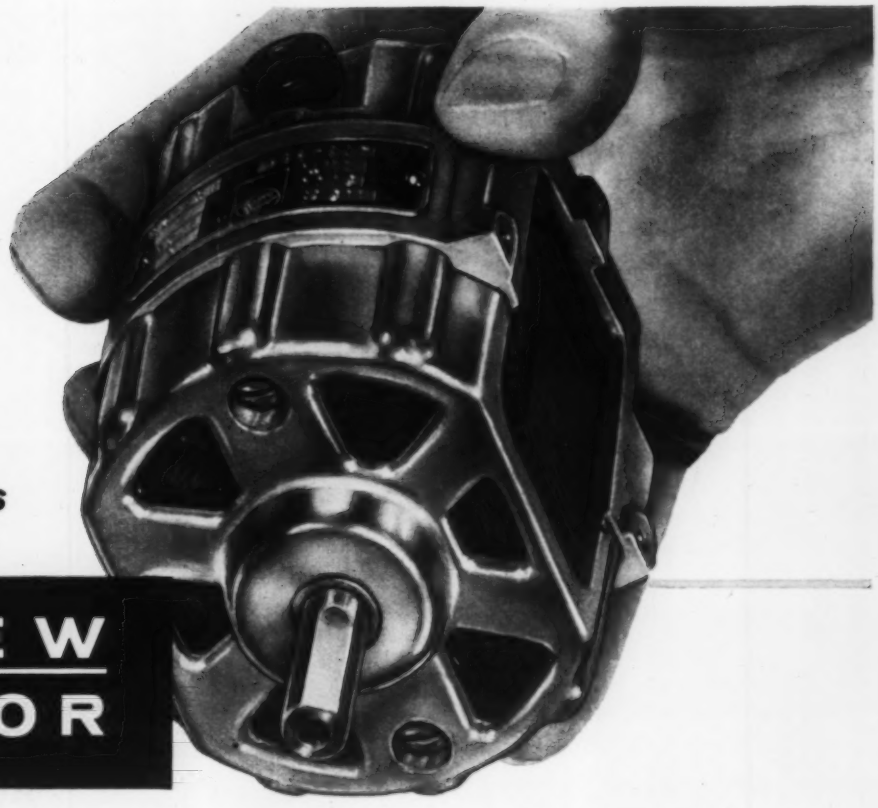
BEARINGS CORPORATION • STAMFORD, CONN.
founded 1911



BODINE
Announces

A NEW MOTOR

Type FSE-23 for intermittent duty applications such as adding machines, calculators, check protectors, check signers and actuators

It's small, only 2 5/16" high . . . it's light, only 1 pound, 11 ounces . . . it's rectangular in shape, fits into minimum space . . . and it packs plenty of power!

The FSE-23 is definitely a Bodine-quality motor . . . yet it's economically priced because it has been designed and engineered for economical, high volume production.

Here's a 33-second thumbnail story of the new Bodine FSE-23 motor:

- series wound
- self-ventilated
- 1/40 horsepower
- 5000 rpm nominal speed
- single direction rotation (clock or counter-clock)
- 115 volts, 60/DC
- two part aluminum die-cast housing
- improved armature and field lamination design for high starting and accelerating torques
- dynamically balanced armatures for reduced motor vibration and noise
- motor shaft extension, 5/16" diameter by 1 5/16" long . . . with .020 flat

the power behind the leading products

BODINE
fractional / horsepower
MOTORS

JUST PUBLISHED! For the complete story of the new Bodine FSE-23 motor, ask for your copy of bulletin No. 1034.

BODINE ELECTRIC CO., 2258 W. Ohio St., Chicago 12

Circle 404 on Page 19

C/R now offers you the advantages of reinforced TFE... designed, compounded and molded by a single source!

If your work involves sealing applications, you are probably familiar with "Teflon", Tetrafluoroethylene Resin. The extreme versatility of its chemical, thermal and mechanical properties are unmatched by any other material on the market.

You may not be, however, fully aware of the degree to which these properties can be distinctly improved by the use of reinforcing inorganic additives. For example, "Teflon" can be blended with inorganics to increase:

- **Resistance to deformation under load — by a factor of 10**
- **Resistance to wear by rotating shafts — by as much as 500 times**
- **Stiffness — by a factor of 4-5**
- **Thermal conductivity — by a factor of 5-10**
- **Compressive strength — by a factor of 3-4**
- **Hardness — by 10%**

It is also useful to know that Chicago Rawhide is one of the few fabricators which blends its own "Teflon" compounds, assuring constant quality in batch after batch and permitting compound formulations to be developed rapidly and accurately. Our new laboratory and production facilities are unexcelled – and these facilities are matched by our experience in molding synthetic parts to meet the most critical specifications.

C/R Sirvene welcomes the opportunity to cooperate with you in the design and production of "Teflon" and reinforced "Teflon" packings, bearings, gaskets, rings, or other parts.

If you are interested in "Teflon" write for your free copy of Sirvene Materials Bulletin CT-1.

*"Teflon" is a DuPont registered trademark

CHICAGO RAWHIDE MANUFACTURING COMPANY
1221 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Manufactured and Distributed by Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario. **Export Sales:** Geon International Corp., Great Neck, New York.
Other C/R Products: *C/R Shaft and End Face Seals • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears*

SIRVENE C/R DIVISION
CHICAGO RAWHIDE

Front Cover: Temperature extremes depicted by red and blue on artist George Farnsworth's front cover act on a restrained cantilever beam to create stress. Featured article is first part of a series by S. S. Manson, beginning on Page 114.

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We can reduce final parts cost through the use of a B&W Extrusion because it cuts machining time and eliminates waste of costly material."

Machining is expensive and wastes material. It is doubly so when it is not necessary. Design engineers should investigate the possibility of using an extruded section as starting material, particularly if expensive or difficult to machine materials such as alloy or stainless steels are involved. In many cases, by using a B&W Extrusion, parts production can be reduced to a mere cutting to length and a few simple finishing operations.

To find out more about how B&W Extrusions can help you design a better product at a lower cost call on any of the local sales offices of B&W's Tubular Products Division or write for a copy of Bulletin TB 413. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

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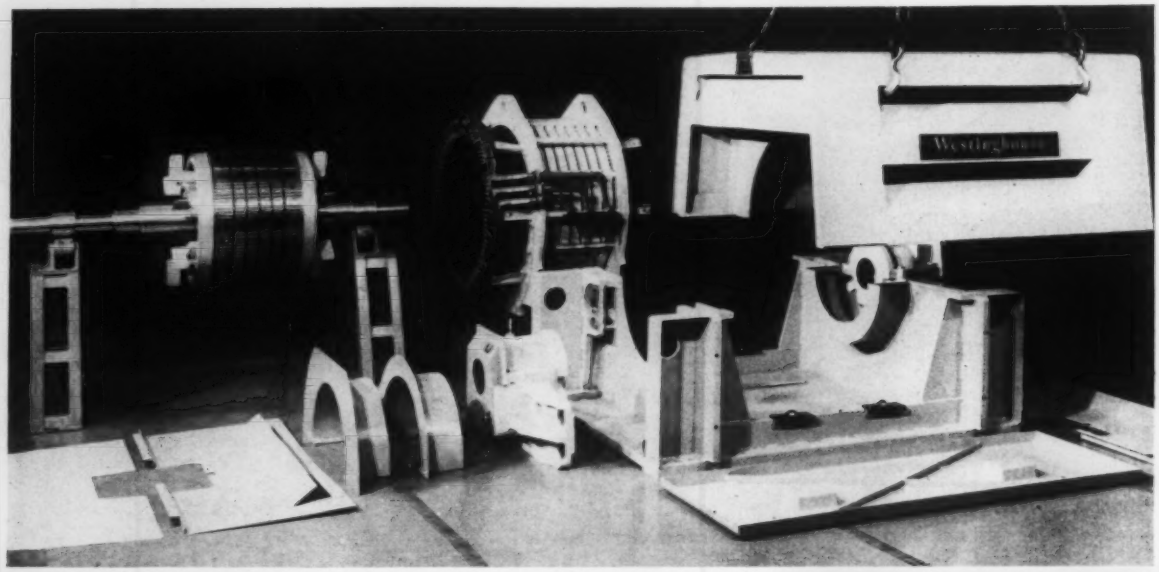
Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals.



Detailed inspection of this Westinghouse "Fully Accessible" large ac motor is relatively simple. Enclosure is merely bolted to the base. All motor parts, including end panels, end covers, and stator can be removed in a matter of minutes. Picture at right shows an assembled 700-hp squirrel-cage induction motor. The new design provides maximum enclosure protection.

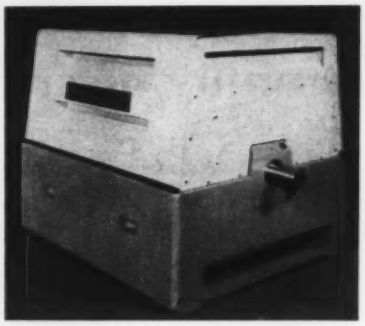
Take-Apart Design of AC Motors Permits Fast, Easy Inspection

PITTSBURGH—A new concept in the design of large ac motors, announced by Westinghouse Electric Corp., permits the motor enclosure to be manufactured independent of the wound stator. During assembly, the enclosure is merely bolted to the base of the motor making the wound stator and all other internal parts fully accessible. As a result, the company's complete line of squirrel-cage, wound rotor, and synchronous motors from 250 to 7000 hp (depending on speed) have been redesigned to use only six basic enclosures and 30 frame sizes as compared to the 450 frame sizes formerly used.

Key advantages claimed for the new "Fully Accessible" motors:

- Stator is accessible for thorough inspection. Enclosures are quickly removed, easily replaced and require no realignment.
- Protruding conduit box is eliminated.
- Noise mufflers, air filters and all types of accessories can be added to the F/A motor without redesign of basic parts.
- Standardization is possible, because each F/A motor frame size replaces 16 of the previous line.

The wound stator of the F/A motor is accurately positioned on the base to give the correct air gap, and is held solidly in place by four locator joints. The bottom part of each joint is welded to the base, and the upper part is welded to the stator. When the stator is removed for inspection, the bolt holding the two parts together is unfastened from each of the four locator joints.



On replacing the stator, it can only go together correctly.

By isolating the stator from the enclosure, transmission of magnetic vibration and noise is minimized, reducing the need for noise mufflers.

Money Is Prime Mover Behind Executive Ability

NEW YORK — "Progress depends on the extent to which the strongest, and not necessarily the highest, forces of nature can be utilized for the increase of social good," according to Dr. Ernest Dale of Cornell's graduate school of business.

Speaking before the Sixty-sixth

new! "projection welded" conveyor chain stays cleaner, runs better, reduces conveying costs!

DIAMOND duraweld Top Plate Conveyor Chain

...streamlined to turn out more work with less worry— in food, beverage, automation, packaging and other small product handling operations.

DIAMOND Dura-Weld is a greatly improved top plate conveyor chain designed for modern high-load, high-speed conveying requirements.

Dura-Weld top plates are "projection welded" to the roller chain linkplates, creating a permanent metal fusion. This technique requires no attachments, rivets or extra fittings which add to the weight and cost of other chains. You get a lighter weight, smoother running chain, that *costs less to buy and less to maintain*—yet is designed to operate continuously at *maximum loads and speeds.*

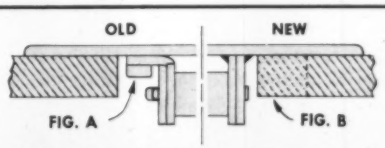
Dura-Weld gives you up to 35% more rail load-bearing area, permitting use of wider supporting rails. Because it has fewer parts to collect dirt it is easier to keep clean . . . and is less susceptible to shutdowns for repairs or maintenance.

Wherever flat top conveyors are used for intra-machine processing, bottling, capping, labeling, etc., you can cut costs and speed up production with new, streamlined, DIAMOND Dura-Weld Conveyor Chain. Write for full details, *today!*

DIAMOND "projection welds" produce a permanent metal fusion as strong as the metal itself. Permits cleaner streamlined design.

Dura-Weld's case hardened bushed joints and deep sprocket engagement assure smooth chain operation under maximum power, load and speed conditions.

Dura-Weld is easily detachable at any joint. Dura-Weld links may be attached to existing roller chain of the same general type and may be used on the same rails.



DIAMOND Dura-Weld requires none of the attachments or rivets shown in Figure A. This permits a simplified design that is easier to keep clean, and gives up to 35% more rail load-bearing area. Permits use of wider supporting rails for greater distribution of load, Figure B.

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Diamond Dura-Weld Conveyor Chain is now available from your Diamond Distributor's stock!

Write for FREE Folder!

Gives complete listing of DIAMOND Distributors and full description, specifications and prices of DIAMOND Dura-Weld Top Plate Conveyor Chain.

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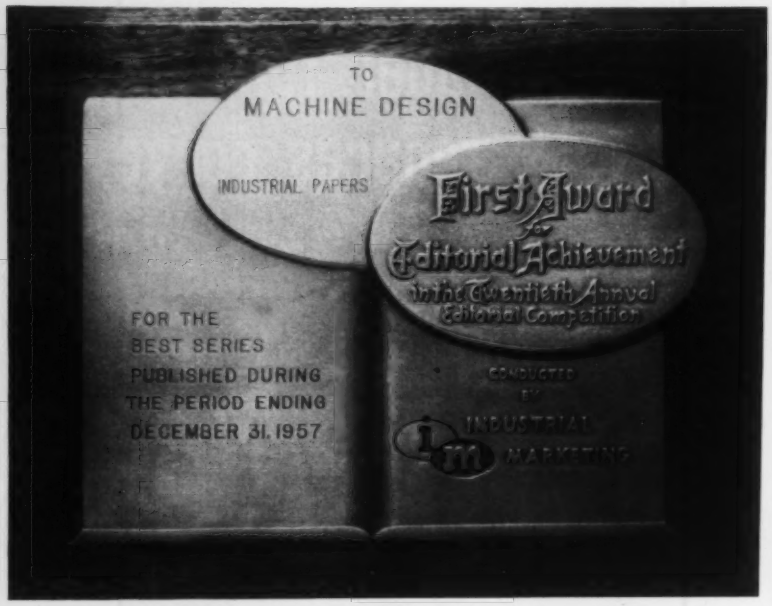


PLAQUE FOR THE BEST SERIES OF ARTICLES entered in the industrial publication division of the 20th Annual Business Paper Editorial Achievement Competition was awarded to *Machine Design* for the series, "Mechanics of Vehicles." This series appeared in 14 issues of *MD*, running from May 30 through December 26, 1957. *MD* also won two certificates of merit in the Competition: The best single issue of 1957—"Design Engineering Show" issue, May 16, and the best single article—"Speed Reducers and Gearmotors," March 21 issue, which was authored by *MD* associate editor William S. Miller.

General Meeting of American Iron and Steel Institute, Dr. Dale declared that, "Just as profitability or maximum return on investment is the fundamental goal of management, managers can be motivated to further that objective if they are rewarded according to their contributions to long-run profit.

"Their contributions can be determined only if men are given responsibility and authority over controllable expenses, in other words, made to stick their necks out," he continued.

"This isn't too difficult in the case of production, sales, or certain other departments. There are some staff groups where it may be more difficult to fix responsibility definitely, but it can be done. One approach might be to judge managers not on the number of programs they are able to 'sell' to top management and have enforced down the line, but on the amount of tangible help they provide for supervisors down the line on real, practical, everyday problems."

Aluminum Foil Welder Used for Packaging

NEW YORK — Aluminum foil can now be welded in continuous seams for packaging applications. Development of a hand-operated aluminum foil welder by Gulton Industries Inc. of Metuchen, N. J., may replace waxing, crimping, or thermoplastic sealing methods now used.

Known as the Ultrasonic Aluminum Foil Welder, it is powered by a 100-w ultrasonic generator. The welder has been tested successfully on aluminum foil down to 0.0003 in. High-frequency sound waves accomplish a molecular transference or plastic flow between two metals, resulting in a welded joint.

One of the greatest potentials for the foil welder, according to company officials, is the use of aluminum for electrical connections. Despite aluminum's excellent electrical characteristics, it has been used sparingly in these applications because it was formerly too difficult to join to other metals.

Topics

Canned time soon will be available at the supermarket. Alarm clocks are being sealed in coffee-type cans by General-Gilbert Corp. to reduce breakage and to prevent drying out of the lubricating oil. Superiority of this armor-like packaging has enabled the manufacturer to extend to one year the usual 90-day guarantee on canned electric and one-day windup clocks.

• • •

Iron Curtain parted slightly to permit a line of instruments and automatic control equipment to be taken to the current Fourth International Automation Exposition at the New York Coliseum. The exhibit, sponsored by the Russian Chamber of Commerce, is the first display of Soviet industrial and laboratory instruments in America.

• • •

Shopper's aid in the grocery-store maze is an automatic direction-giver installed in some California supermarkets. A pushbutton directory, it provides prerecorded directions to any of 190 items in stock.

• • •

Man on the moon will contaminate it with earth germs and bacteria; therefore scientists are seeking a method of sterilizing the first lunar rockets. It may be possible to sterilize the interior of a rocket by heat or fumigation; heat of air friction would take care of the exterior. Another, longer-range problem is that of contaminating our earth with planetary forms of life brought back by rockets making round trips.

• • •

Tee time, 1958, brings a helpful hint for improving your golf game: A golf ball can be hit farther if it has been bombarded with high-intensity gamma rays.

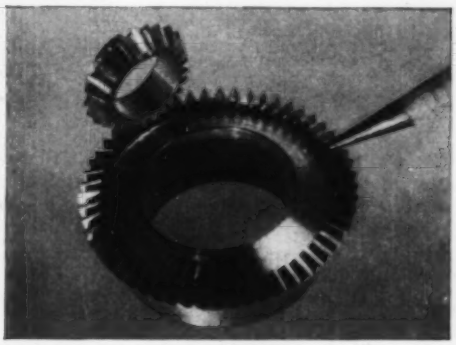
• • •

Modern manna: Water, fuel, or other liquid can be dropped in newly developed rubber containers to people who are stranded. Saucer-shaped containers are 30 in. in diam, hold 5 gal, and have oil-resistant liners for petroleum, rubber liners for water. These "falling saucers" have been dropped 2000 ft in tests without bursting.

• • •

Outdoor-type turbine-generator is the first in the U. S. to be atomic-powered. It is housed in a quonset-hut-shaped structure apart from the main building of the first full-scale U. S. central station nuclear power plant recently dedicated at Shippingport, Pa. The turbine-generator, built by Westinghouse, has a capability of 100,000 kw; the power station is producing 60,000 kw net electrical output.

CURVIC COUPLINGS provide an accurate, light, compact, and self-contained connection in which the teeth both center and drive. The Curvic design represents a new standard in the application of coupled parts.



BEVEL GEARS

When a gear or a coupling determines the *accuracy of trajectory*...

When a missile or rocket works on paper the best way to get it into the air is to see to it that all the parts agree with the paper work.

And when one of those parts is a bevel gear or coupling, Gleason engineers can help you three ways:

1. Engineering service. Our full staff of engineers is ready at all times to help you develop bevel gear combinations and Curvic® Coupling designs. They can help you make sure that either part meets your specifications.

2. Machines to cut or grind to your tolerances. You can produce any fine pitch gear—spiral bevel, hypoid, Zerol® or Coniflex®—precisely and economically with any of five Gleason machines.

No matter how rigid your specifications or the size of your parts, our engineers can help you select the right machine or combination of machines for 100% accuracy.

3. Complete testing equipment. We have engineered a series of testers for making certain that all parts do meet your critical specifications. For example, on the Gleason No. 104 Hypoid Tester you obtain a permanent test record to help you match pairs properly and to keep a graphic record of the rolling qualities, tooth spacing, and concentricity of your parts.

Any or all of these services are yours for the asking at any time.

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

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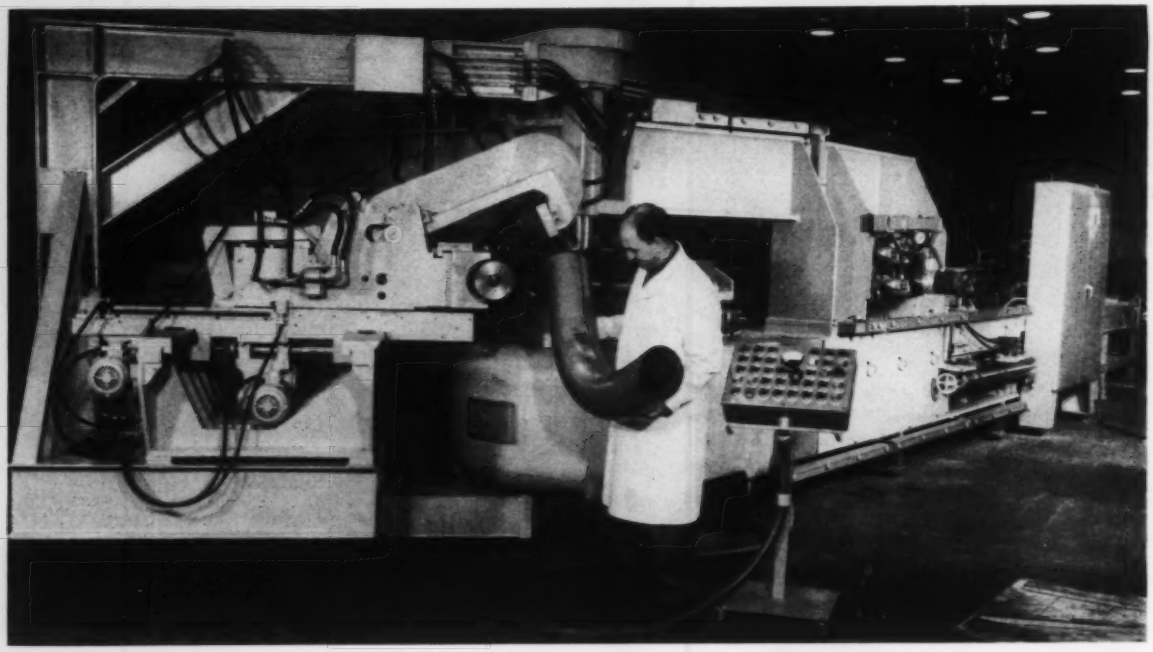


BIG BENDER forms ultra-thin 8-in. OD x 0.020-in. stainless-steel tubing used extensively for air and fuel ducting in jet aircraft. The new seamless tube components will replace welded units currently made in a half-shell stamping process. Bender is hydraulically operated and features a separate set-up control panel which permits accurate dial pressure settings for clamp die, pressure die, and tube booster operations. All tool carriages are motorized and controlled by pushbutton from the main control stand. Operations can be jogged or cycled. For automatic single-cycle operation, a bend can be made to a predetermined angle by pressing a single pushbutton. The machine was designed and built by Pines Engineering Co., Aurora, Ill.

Metals Matters

Bright, lustrous finish on high-alloy steels is produced by the Cor-A-Brite process, developed by Roto-Finish Co., Kalamazoo, Mich. Ground high-alloy steel bearings, with a microinch reading of 10 rms, can be processed to produce a bright surface with a microinch reading of 2 rms. The entire Cor-A-Brite process is completed with one chip mass in one standard barrel finishing machine, which eliminates handling parts between several different operations and assures uniform appearance and finish of the workpieces.

• • •

New superalloy developed by Westinghouse, Nicrotung, is expected to permit raising the operating temperature of jet engine turbine blades to 1800 F. This increase of about 150 deg over present jet-engine operating temperature approximately equals the total increase in operating temperatures made in such engines in the last five years. Nicrotung, composed essentially of nickel, chromium, and tungsten, satisfies requirements of castability, oxidation resistance, stress-rupture strength, and ductility. At 1700 F it withstands a stress of 32,000 psi for 100 hr; at 1800 F, it withstands 22,000 psi stress for 100 hr.

• • •

Alloy for brazing gaps—up to 0.05 in.—is announced by Wall Colmonoy Corp., Detroit. W. G. Nicrobraz, suitable for high-temperature service, is recommended for use in nonrotating, lightly loaded parts and structural assemblies with 1/16 in. or thicker cross sections. It is well suited for applications where large fillets are desired. The material is available as a powder or in the form of impregnated plastic wire.

• • •

Freezing a blast furnace in the middle of its reduction cycle and taking samples of the contents is affording a unique opportunity for examining the process of converting ore to iron. Contents of a hot, operating furnace were quenched with a blast of nitrogen, loose material was removed for analysis, and the 5200-lb solid mass of coke, metal, and slag in the furnace hearth was sampled by core-drilling. Preliminary observations have been made of the distribution of coke and raw materials in the furnace; further studies will provide details on various phases of the process. This probing of the mysteries of iron-making was accomplished through the combined efforts of U. S. Steel scientists, Linde Air Products technicians, and an experimental blast furnace of the U. S. Bureau of Mines.

• • •

High electrical conductivity and corrosion resistance are distinctive properties of a new aluminum-covered steel wire, called Alumoweld, to be marketed by Copperweld Steel Co., Columbus, Ohio. Battelle Memorial Institute developed the process for the new wire. According to Copperweld, the aluminum can be applied to thicknesses not previously possible. Exceptional ductility is explained by the absence of brittle compounds at the juncture of the two metals. The coating process is continuous—lends itself to automation.

Cold Extrusion from

ARISTOLOY 5120

Cut Machining and Material Cost

To Molloy Manufacturing Co., cold forming of automotive parts like this steering worm called for steel with unusual cold working qualities. Uniformity and absence of surface defects were, of course, necessary . . . but closely controlled conditioning and annealing were absolutely vital. Copperweld, one of the electric furnace steel producers working on this problem, developed special processing methods that produced a steel which met Molloy's cold extruding and upsetting requirements. The production proof . . . parts like these, cold extruded and upset from a $^{29}/_{32}$" round to a finished maximum diameter of 1.440", with substantial savings in material and machining time.

Investigate the wide range of Aristoloy A.I.S.I. analyses for extrusion application. Then call or write for assistance from a Copperweld Field Metallurgist in selecting the best material for your job.

ARISTOLOY STEELS

COPPERWELD STEEL COMPANY • Aristoloy Steel Division

4017 Mahoning Avenue, Warren, Ohio • *EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.*

FAST INSPECTION OF HIGH-SPEED CAMS solves a major problem in computer production at IBM. Inspection of typical 12 in. long by 3 in. diameter printing cam involves precise measurement of 4320 points around cam diameter. Tolerances run to 0.0001 in. Formerly a 12-hr job, inspection takes 12 min on the new cam analyzer. Three electronic gage heads reference revolving cam to master. Dimensional differences are picked up by gages and recorded by supporting equipment. IBM designed mechanical portions of the new machine. Gaging components were supplied by Airborne Instruments Laboratory, Mineola, N. Y.

Find Unexpected Phenomena In Satellite Tracking

Los Angeles—Various unexpected phenomena have been recorded in the tracking of Sputnik I and Explorer I, although in general the tracking network performed its job as designed. Signals from Sputnik I, broadcast on 20 and 40 mc, would get trapped under the ionosphere, making it possible for stations a long distance away to hear the satellite for extended periods. Reports from ½ hr to 1½ hr were fairly common, according to Eberhardt Rechtin of the Jet Propulsion Laboratory of Pasadena, Calif., in a paper presented before the American Rocket Society.

Very small, low-level signals would appear about 30 sec before the main satellite signal could be heard. This precursor, probably caused by an ionospheric trapping effect, was a reasonably reliable warning that the satellite was about to appear.

There was also a so-called "ghost satellite." Under certain conditions, a signal would show up 180 deg away on the earth from the true position of the satellite. Except that the satellite was not overhead, the signals had much the same characteristics as though it were.

Explorer I signal strengths were not as predicted. The signal had fades about every 7 sec, which increased in depth of fade until they reached a fairly stable action some days later. One of the strangest things to occur in Explorer I was the resurgence of an apparently dead transmitter. The higher power transmitter experienced a normal life history for the first several weeks. But at the end of this time, because resistance of the dead mercury battery decreased to zero, the second battery was able to drive the first. The transmitter lasted until the second battery was also exhausted.

Soviets Say Sputnik III Measures Upper Atmosphere

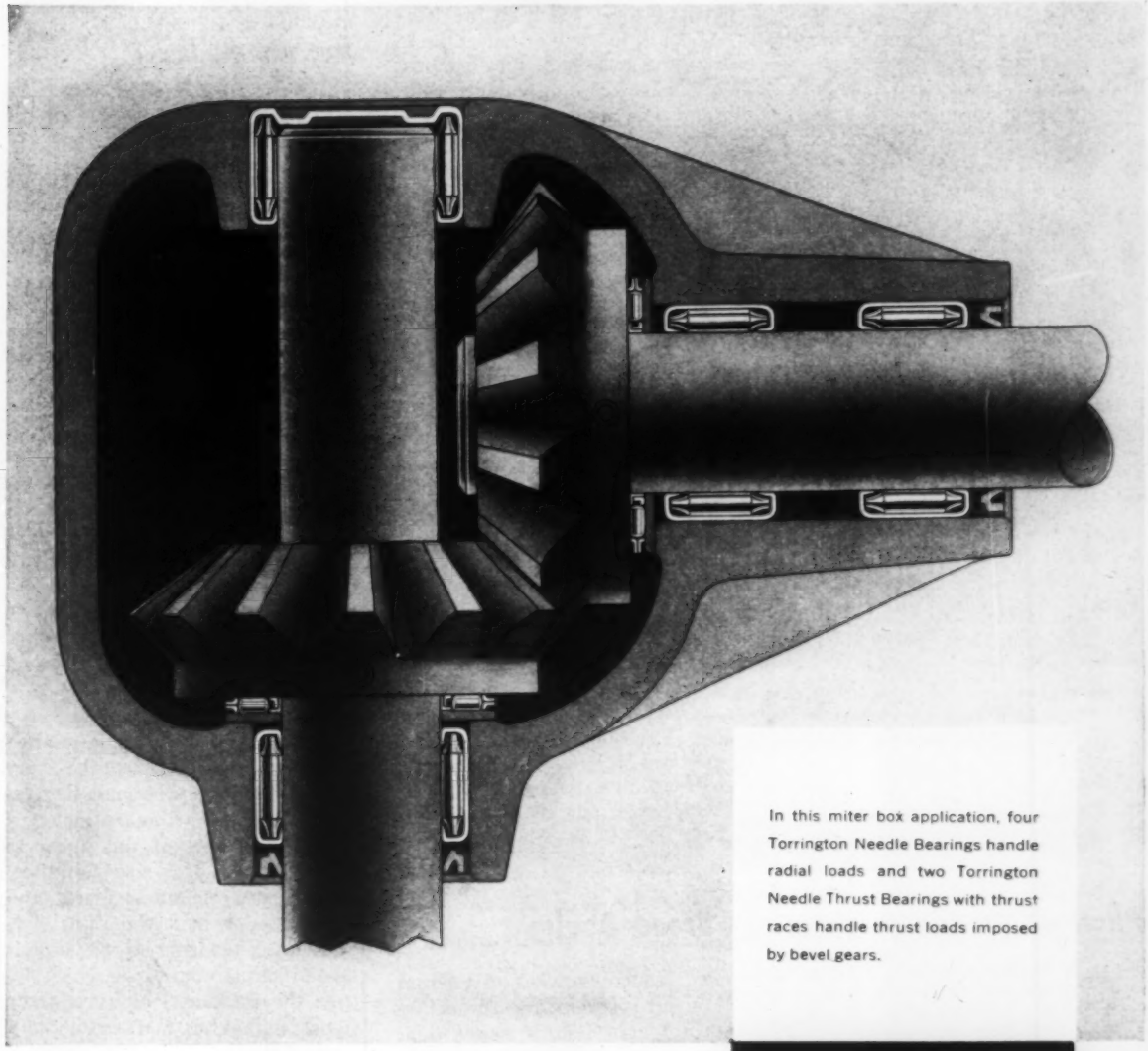
Moscow — Equipment aboard the 2925-lb Sputnik III is designed to study the upper layers of the atmosphere and cosmic space, according to a recent Soviet announcement. Total weight given for the satellite includes 2133 lb for combined weight of the instruments, radio-measuring apparatus, and power sources.

Research studies to be aided by satellite - instrument measurements are diverse: 1. Pressure and composition of the upper layers of the atmosphere. 2. Concentration of positive ions. 3. Magnitude of the satellite's electric charge and intensity of the earth's electrostatic field. 4. Intensity of the sun's corpuscular radiation. 5. Composition and variation of primary cosmic radiation. 6. Distribution of photons and heavy nuclei in cosmic rays. 7. Micrometeors. 8. Temperature inside the satellite and on its surface. 9. Intensity of the earth's magnetic field.

Radiotechnical apparatus aboard the satellite is said to be controlled by a programming device. A multichannel telemetric system relays data to recording stations on earth. Temperatures required for normal operation of the instruments are maintained by a thermoregulator system, which reportedly changes the coefficients of surface radiation and reflection.

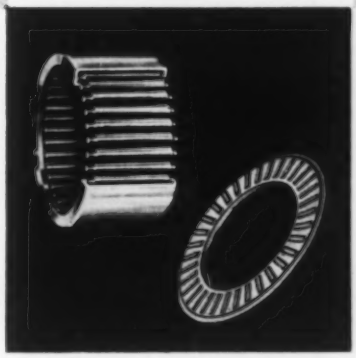
Chemical thermodynamic properties of a great number of materials are being listed by the National Bureau of Standards in a program supported in part by the Atomic Energy Commission. Object of the program is to present, in convenient tabular form, a critical summary of the thermodynamic information available on each chemical substance over as wide a temperature range as possible.

The tables compiled by the Bu-



In this miter box application, four Torrington Needle Bearings handle radial loads and two Torrington Needle Thrust Bearings with thrust races handle thrust loads imposed by bevel gears.

Perfect Combination for Thrust and Radial Loads



Here's a space-saving, cost-saving way to handle high thrust and radial loads. Just team up Torrington Needle Bearings with Torrington Needle Thrust Bearings!

With their full complement of small diameter rollers, Needle Bearings handle higher radial loads than any other anti-friction bearing of comparable cross section. And Needle Thrust Bearings are only .0781" thick – as thin as an ordinary thrust washer. Together they make a perfect combination of compact, light, rugged anti-friction bearings.

Either type of bearing may be run on hardened and ground adjacent parts to meet minimum space requirements. Or they may be used with standard races available from Torrington. To make the most of this efficient combination, call on our engineering staff for application advice.
The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.

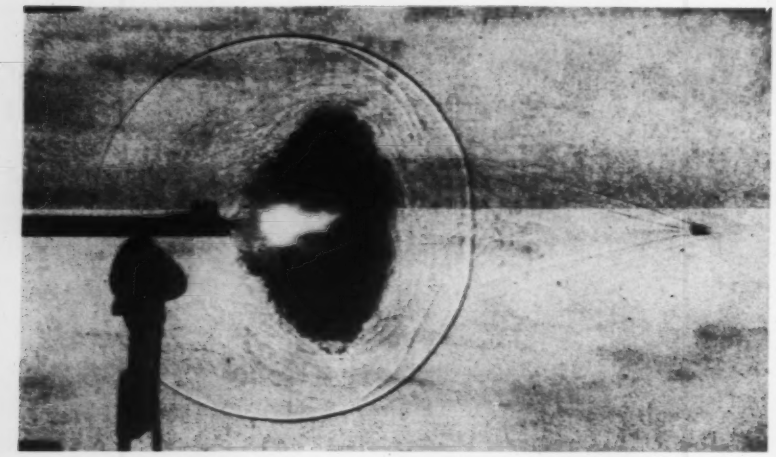
TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS • THRUST

Circle 410 on Page 19

reau contain values of heat content function, free energy function, entropy, heat capacity, and heat and free energy of formation. For each substance the values are given at regular intervals of temperature from 0 to 6000 K in some instances. From these data, answers may be obtained to questions regarding stability, equilibrium compositions, and energy yields in this temperature range.



Shock waves caused by the firing of a 22-caliber bullet have been recorded by a new technique developed by Dr. Harold E. Edgerton. Dark vertical object at left is microphone which "triggered" electronic strobe light when shock wave hit it. Just above the microphone is the barrel of the rifle. Large circular shock wave (left center) was caused by the expanding gases which fired the bullet. The bullet itself is small dark object at right center. Two shock wave "wakes" can be seen flowing back from its edges.

Photographs Shock Waves in Broad Daylight

Uses Light Refraction, Scotchlite Screen

CAMBRIDGE, MASS.—Shock waves are now photographed in broad daylight with the aid of a technique, newly developed by Dr. Harold Edgerton of MIT. The system makes it possible to take full-scale pictures of the shocks caused by rocket sled tests or by actual aircraft in flight.

The shock wave is simply a sudden change in the pressure and density of the air caused by the object moving through it. Because the speed of light is different in air of different densities, light is deflected from a straight line when it passes from one density to another. Thus, passing a ray of light through denser than normal air—the shock wave—causes it to bend.

The new system uses very simple equipment, a small volume, short-exposure electronic flash at the lens of a camera, and a black Scotchlite screen. Scotchlite, which is used on reflective road signs, has the ability to reflect light from a source right back to the source itself.

To get his pictures, Dr. Edgerton sets up a Scotchlite screen facing the camera and places a small high-speed light as near the camera as possible. This light is sent through the shock wave to the screen and is then reflected back to the camera. Any bending of the light caused by the shock wave shows itself on the background as a shadow which is then photographed.

One conventional method of taking pictures of shock waves is called Schlieren photography. This system is used in wind tunnel research and employs an expensive and delicate optical system. Schlieren can be used only with the tunnel for which it is adapted and only with small-scale models. The Edgerton system, on the other hand, can be set up almost anywhere and can be used with full-scale aircraft.

Microwave Amplifier May Improve Radar

Offers Special Advantages From 1000 to 10,000 Mc

NEW YORK — A significant advance in microwave amplifying techniques may reduce the size and improve the performance of radar equipment for missiles, satellites, and aircraft. Developed by the RCA Laboratories at Princeton, N. J., the advance is said to be a basic improvement in a solid-state device known as a parametric microwave amplifier.

Currently, microwave amplification is accomplished with traveling-wave tubes or with masers. According to RCA scientists, the improved parametric amplifier now promises to supplement these two techniques, offering particular advantages in the range of 1000 to 10,000 mc and higher—a range which includes almost all types of radar equipment.

Previously, parametric microwave amplifiers were considered impractical for operation at the very highest frequencies because they required a local-oscillator frequency higher than that of the signal to be amplified. The new technique permits use of an oscillator frequency lower than the signal frequency. It consists of an experimental germanium diode which detects the incoming, high-frequency signal and either a transistor or a "pencil-type" tube oscillating at a lower frequency to provide the "pumping" action which amplifies the signal.

The new device is claimed to have all of the advantages attributed to the parametric amplifier using higher frequency pumping, and far greater flexibility. Parametric amplifiers do not require the extremely low temperatures needed in the maser technique, in which liquid helium is used, and they require no magnetic field. Further reported advantages of the new device include a power requirement of only a fraction of a watt as compared to a hundred watts or more for present conventional microwave amplifiers. Also, the new unit can be packed into a space of only 4 cu in., opening new opportunities for miniaturization. It has been tested in uhf and 6000-mc regions.

Navy's Newest Submarine Features Aerodynamic Design

Safety Belts Required For Underwater Flying

GROTON, CONN. — An aviator would be at home on the new atomic submarine *Skipjack*, according to her designers, General Dynamics' Electric Boat Div. *Skipjack's* operator will be called a pilot, her cruises will be logged as "flights," and the submarine itself will be referred to as the "flying A-sub."

Launched May 26, *Skipjack* will be controlled by a joy stick while performing "hydrobatics," and the pilot, co-pilot, and other operators will be fastened into their seats with safety belts. The sub is equipped with an automatic pilot and her remarkable hull design was tested in a wind tunnel by NACA. Her exact speed is classified but submariners say it puts her in the "jet class" of the Navy's underwater fleet. Officially, it is listed as over 20 knots.

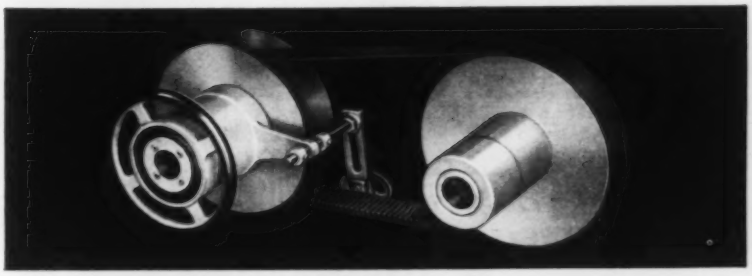
Automation is a predominant feature in the new sub. To fill ballast tanks and submerge, a crewman merely pushes a series of buttons. A similar procedure is followed to empty the tanks for surfacing. The pilot, after deciding the submarine's course, speed and depth, can set the automatic pilot and monitor the sub's progress.

Electronic and hydraulic monitors watch motors, air conditioning, refrigeration, gas systems and the numerous fail-safe devices on the nuclear power plant. Individual zone air-control regulators keep the air fresh and pure.

Actually, says Electric Boat, *Skipjack* is a veritable "submerged space station."

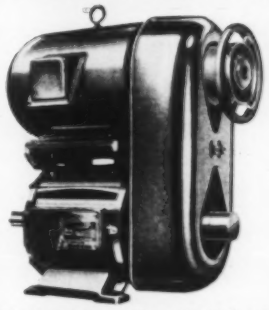
Space life existence under actual working conditions was proved a reality when the hatches were opened on two nuclear submarines, the USS *Seawolf* and *Skate*, according to Adm. Arleigh A. Burke. Their return from exercises, during which each craft completed over 30 days submerged operations without contact with the earth's atmosphere, is the longest known period in which man has been exposed to an artificial atmosphere under actual operating conditions.

DIRECTLY APPLY VARIABLE SPEEDS



LEWELLEN

COMBINATION PULLEYS



Motion-controlling Cycledyne with variable speeds

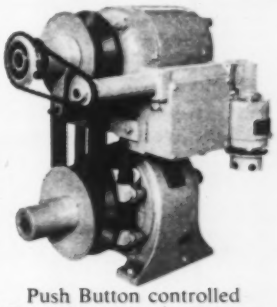
Connect any two shafts—incorporate infinitely adjustable speed ratios.

Control speed settings while running—accurately, conveniently.

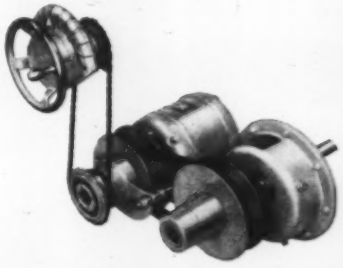
Equip for flexible operation—compactly, economically.

SPEED RANGES TO 10:1
RATINGS TO 15 H.P.

Handwheel controlled Medor Screw Conveyor



Push Button controlled Foote Vari-Mount Reducer



Chain Shifter controlled Falk shaft-mounted Reducer

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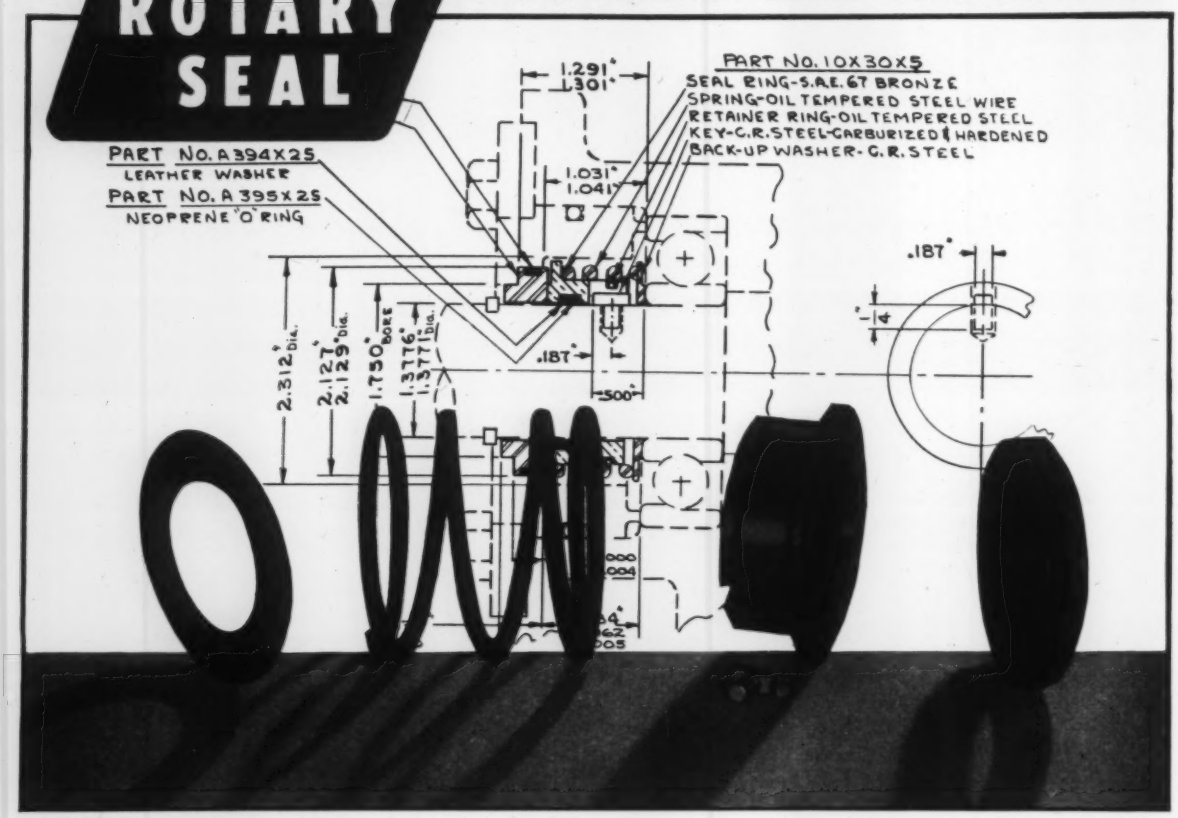
MANUFACTURING COMPANY
Columbus, Indiana

Distributors In All Industrial Areas In Canada—Peerless Engineering Sales, Ltd., Toronto-Montreal

ROTARY SEAL

SPECIALIZED SEAL ENGINEERING



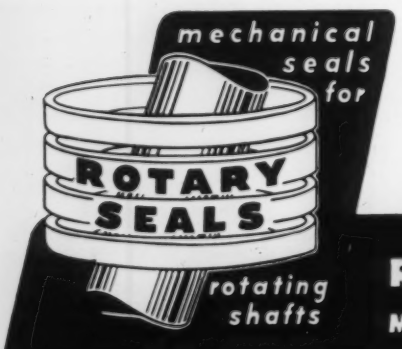
is developing new ways to assure top performance in HIGH-PRESSURE HYDRAULIC OIL PUMPS

In modern pump design, pressures keep climbing, overall sizes keep shrinking—and the Shaft Seals must be better designed to handle tougher operating conditions.

Take a Seal like that illustrated: it's one of a series developed by ROTARY SEAL engineers, for heavy-duty pumps which activate big 'dozers and similar equipment. High pressures provide higher out-put efficiency; and the Seal must take the whole load—no shunting or bypassing part of it—yet must be designed to take up less space in extra-compact units.

You can't reach back on the shelf for a Shaft Seal when your pump—or your compressor, or whatever your unit may be—must measure up to tougher modern specifications. It takes a *custom-designed* Seal—fitted in every detail to the specific job at hand. ROTARY SEAL specializes in developing and manufacturing Seals to meet such problems, by applying the basic ROTARY SEAL principles which opened the way to successful mechanical Shaft Sealing when this company introduced them years ago.

The best time to start solving your Shaft-Sealing problem is at the drawing-board stage. Call in our engineers for an early consultation—our experience with Seal applications of all kinds in many fields often indicates suggestions which can simplify design, lower costs and improve performance.



Shaft-Sealing with Certainty

ROTARY SEAL DIVISION
MUSKEGON PISTON RING CO., SPARTA, MICHIGAN

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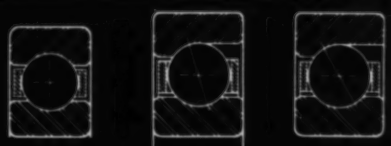
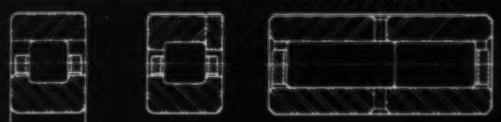


Conrad design, types LC, HC and BLC

Maximum capacity design, types HM, BLM

Angular contact design, types HA, BLA

RADIAL ROLLER BEARINGS

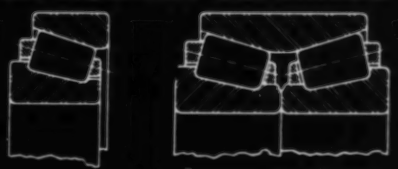


Lipped inner, straight outer race types RN, RX and RNW

Lipped inner, one lip outer, side ring type RP

Straight inner, straight outer, mill type RM

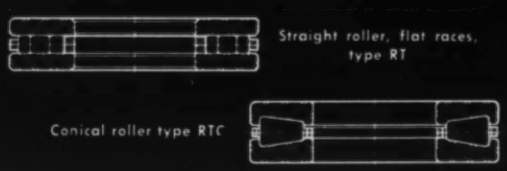
TAPER ROLLER BEARINGS



Single row type TS

Two row, non-adjustable type TNA

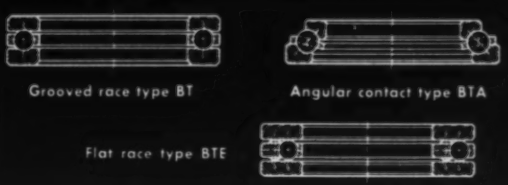
THRUST ROLLER BEARINGS



Straight roller, flat races, type RT

Conical roller type RTC

THRUST BALL BEARINGS



Grooved race type BT

Angular contact type BTA

Flat race type BTE

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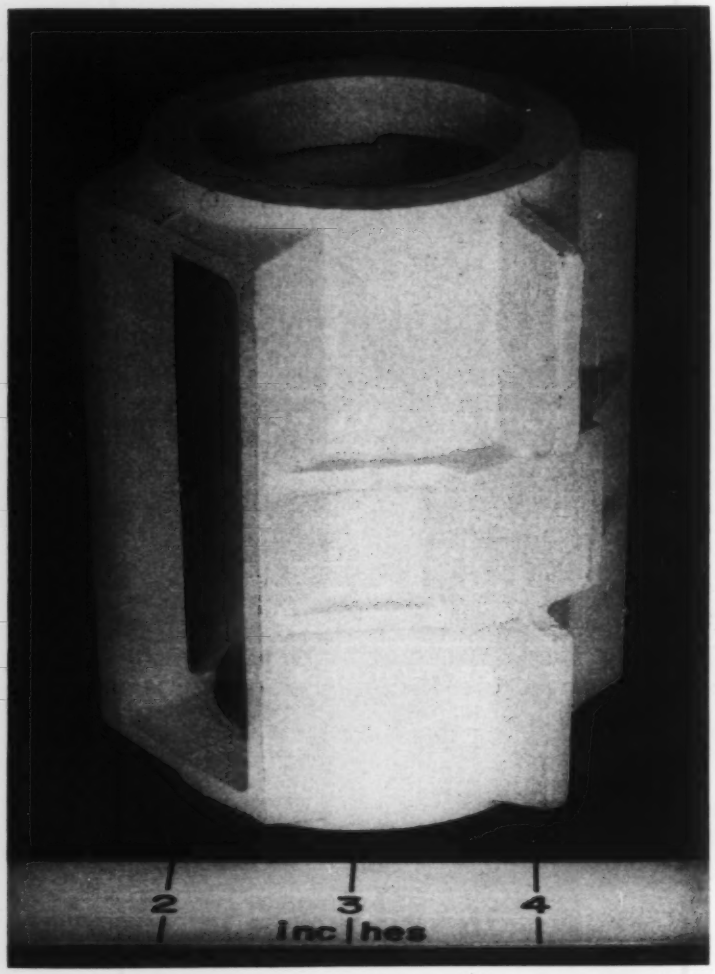


Fig. 1—Configuration of test parts cast by normal foundry techniques and by new high-strength, high-ductility technique

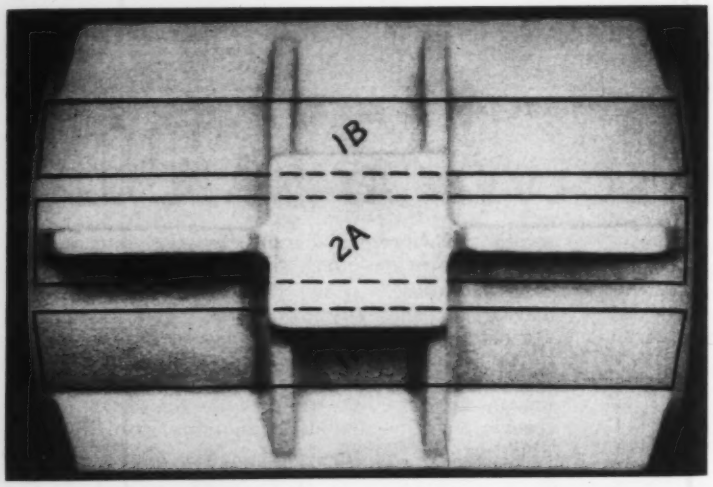


Fig. 2—Locations of test bars taken from test castings

Super-Strong

HIGH STRENGTH AND HIGH DUCTILITY distinguish a grade of light-alloy sand castings now being produced with newly developed foundry techniques. Guaranteed minimum mechanical properties of the castings are substantially above requirements of pertinent Federal specifications.

Major advantages of the process are that improved mechanical properties and soundness are obtained in the castings themselves, and optimum reproducibility is obtained from casting to casting. The process permits the casting of intricate parts, large or small, with excellent surface finish.

It is expected that these castings will be used primarily as substitutes for parts which are presently cast by other methods, but where a weight saving or greater reliability would be advantageous. Also, they may replace parts which are presently forgings or weldments.

The new techniques have been developed largely from the results of a six-year basic research program performed in the M.I.T. Foundry

By close control of process variables, new foundry techniques make nonferrous castings stronger, more ductile than Federal specification requirements

Light-Alloy Castings

By **MERTON C. FLEMINGS** and **HOWARD F. TAYLOR**
Assistant Professor Professor
Massachusetts Institute of Technology
Cambridge, Mass.

Laboratory and sponsored by the Pitman-Dunn Laboratory, Frankford Arsenal. In recent projects sponsored by the Instrumentation Laboratory, M.I.T., many of the results have been translated to production castings of various alloys.

Light Alloy Techniques

High-strength, high-ductility castings may be produced readily in any high grade nonferrous sand (or plaster) foundry. Basic requirements are that the foundry have adequate controls and competent technical personnel. Essentially, the casting process involves refinement of well-known foundry techniques to the point that sound, fine-structure castings free from deleterious inclusions may be produced consistently, regardless of how intricate the patterns may be. In practice, the foundry must exercise strict control over alloy analysis, melting variables, gating, molding, chilling and risering, and heat treatment.

Laboratory and pilot production tests have shown that the techniques for producing high-strength, high-ductility castings are adaptable to a variety of nonferrous alloys. These include aluminum alloys 356 and 195, and magnesium alloys AZ91C and AZ92A. In the case of 356 alloy, the laboratory results have already been translated to the production of quantity lots of castings. It is now possible to obtain these high-quality 356 alloy castings from a number of commercial sources.

Aluminum Alloy 356 Castings

Federal Specification QQA-601a-3 requires that separately cast test bars of 356 alloy have mechanical properties of 30,000 psi tensile strength, 20,000 psi yield strength, and 3 per cent elongation. Test bars cut from a production casting need average only 22,500 psi tensile strength, 15,000 psi yield strength, and 0.75 per cent elongation. Individual bars in the casting may be even weaker as long as the average meets the specification.

To compensate for these areas of weakness, the designer who does not employ the new techniques must add a "casting factor" in addition to his safety factor. That is, he must increase the weight. Often, he must use means of fabrication other than casting to obtain a requisite strength-to-weight ratio.

The new foundry techniques make it possible to obtain 356 alloy sand castings with mechanical properties well above those in the Federal Specification. Moreover, these properties are guaranteed in the casting itself, so the "casting factor" is unnecessary. Several commercial foundries using the techniques are guaranteeing mechanical properties in 356 alloy castings as high as 38,000 psi tensile strength, 28,000 psi yield strength, and 5 to 6 per cent elongation.

An example of improvement of casting quality obtained by these foundry procedures is illustrated in Fig. 1. This part was first cast in a good commercial foundry using conventional foundry techniques. Mechanical properties of a sepa-

rately cast test bar met the specifications of QQA-601a-3, and radiographs of the casting showed no indication of microporosity or other defects. Test bars were cut from the casting as shown in Fig. 2. Average mechanical properties were 25,200 psi ultimate tensile strength, and 1.5 per cent elongation. Minimum properties were 22,200 psi ultimate, and 1 per cent elongation.

Following this test, the same part was produced by a second commercial foundry using the new techniques for producing sand castings of optimum quality. This casting was similarly tested. Mechanical properties of bars cut from the casting averaged 41,300 psi tensile strength, 33,700 psi yield strength, and 8 per cent elongation. Minimum properties were 40,700 psi tensile strength, 32,700 psi yield strength, and 6 per cent elongation. The special techniques resulted in an 83 per cent increase in minimum tensile strength and a 500 per cent increase in minimum elongation. Properties of both test castings are compared in Table 1.

Table 1—Mechanical Properties of Two 356 Alloy Castings

Test Part	Test Bar Location*	Tensile Strength (psi)	Yield Strength (psi)	Elongation (% in 2 in.)
Commercial Casting	1A	27,600	.....	2
	1B	25,800	.....	1.5
	2A	22,200	.....	1.0
	Average	**25,200**	.....	**1.5**
High-Strength, High-Ductility Casting	1A	41,200	32,700	7
	1B	40,700	34,100	6
	2A	42,000	34,200	11
	Average	**41,300**	**33,700**	**8**

*Location numbers refer to Fig. 2.

Table 2—Guaranteed Minimum Mechanical Properties

Alloy	Form	Tensile Strength (psi)	Yield Strength (psi)	Elongation (% in 2 in.)
Federal Spec. QQA-601a-3 (aluminum base)	356 Average from castings	22,500	15,000	0.75
	195 Average . . .	24,000	15,000	0.75
Federal Spec. QQ-M-56(a) (magnesium base)	AZ91C Average . . .	25,500	14,500	0.75
	Minimum . . .	17,000	12,000	0
	AZ92A Average . . .	25,500	16,000	0
	Minimum . . .	17,000	13,500	0
High-strength, high-ductility*	356 Minimum . . .	38,000	28,000	5.0
	195 Minimum . . .	43,000	27,000	6.0
	AZ91C Minimum . . .	35,000	17,000	2.0
	AZ92A Minimum . . .	30,000	18,000	1.0

*These properties obtained in areas designated by the designer, or throughout the casting when required, if the casting is less than 30 lb in weight and section thicknesses are under 1 in.

Castings of Other Alloys

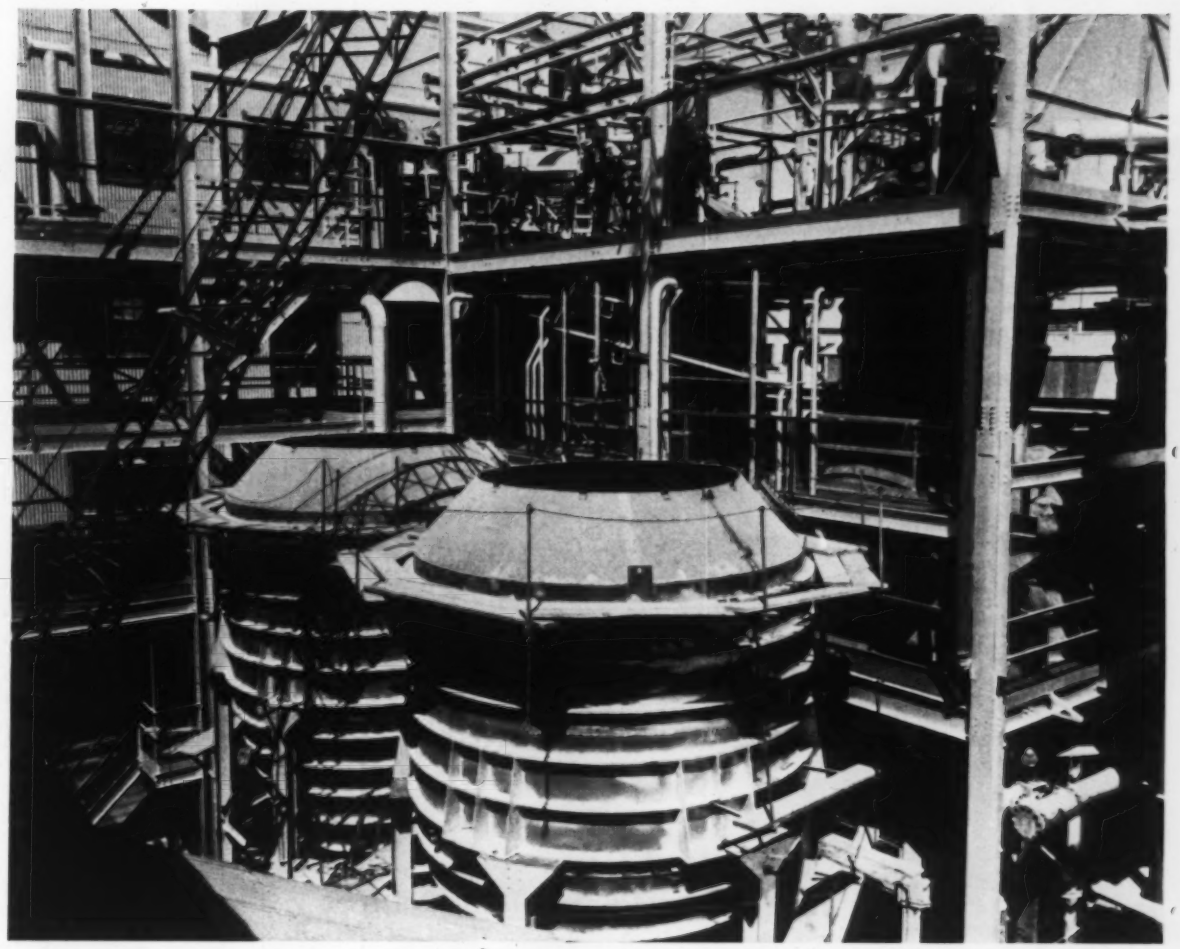
The techniques for producing high-strength, high-ductility 356 alloy castings may be used with success on other casting alloys. For example, it should be possible to guarantee minimum mechanical properties in 195 alloy castings of 43,000 psi tensile strength, 27,000 psi yield strength, and 6 per cent elongation. Corresponding average mechanical properties required by Federal specifications are 24,000 psi, 15,000 psi, and 0.75 per cent.

Recently, the possibility of adapting the techniques to the production of high-quality magnesium alloy castings has been investigated in the M.I.T. Foundry Laboratory, on a pilot production scale. Results to date indicate that guaranteed minimum mechanical properties of AZ91C and AZ92A alloys may be substantially raised by use of the process. For example, Federal specification requires average properties in AZ91C alloy castings to be 25,500 psi tensile strength, 14,500 psi yield strength, and 0.75 per cent elongation. Individual test bars may be as low as 17,000 psi tensile strength and 12,000 psi yield strength, with no elongation requirement. New casting techniques should permit guaranteeing minimum mechanical properties in AZ91C castings of 35,000 psi ultimate tensile strength, 17,000 psi yield strength, and 2 per cent elongation.

Table 2 summarizes minimum mechanical properties in pertinent Federal specification and high-strength, high-ductility specifications for a variety of alloys.

Details of the new foundry techniques for high-strength, high-ductility, light-alloy castings appear in the following references:

1. W. D. Walther, C. M. Adams, and H. F. Taylor—"Effect of Casting 'Fiber' on Mechanical Properties of Aluminum-4 Per Cent Copper Alloys," *A.F.S. Trans.*, Vol. 61, 1953, pp. 664-673.
2. H. F. Taylor, W. D. Walther, and C. M. Adams—"Techniques for Improving Strength and Ductility of Aluminum Alloy Castings," *A.F.S. Trans.*, Vol. 62, 1954.
3. D. Chandley, C. M. Adams, and H. F. Taylor—"A Quantitative Evaluation and Importance of Hydrogen in Aluminum Founding," *A.F.S. Trans.*, Vol. 63, 1955, pp. 607-614.
4. M. C. Flemings, P. J. Norton, and H. F. Taylor—"Performance of Chills on High Strength-High Ductility Sand Castings of Various Section Thicknesses," *A.F.S. Trans.*, Vol. 65, 1957.
5. M. C. Flemings, P. J. Norton, and H. F. Taylor—"Rigging Design of a Typical High Strength, High Ductility Aluminum Alloy Casting," *A.F.S. Trans.*, Vol. 65, 1957.
6. M. C. Flemings, R. W. Strachan, E. J. Poirier, and H. F. Taylor—"Performance of Chills on High Strength Magnesium Alloy Sand Castings of Various Section Thicknesses," submitted *A.F.S.*, 1958.
7. M. C. Flemings, R. W. Strachan, E. J. Poirier, and H. F. Taylor—"Rigging Design of High Strength Magnesium Alloy Castings," submitted *A.F.S.*, 1958.
8. S. Z. Uram, M. C. Flemings, and H. F. Taylor—"Effect of Pressure During Solidification on Microporosity in Aluminum Alloys," submitted *A.F.S.*, 1958.
9. E. M. Passmore, M. C. Flemings, and H. F. Taylor—"Fundamental Studies on Effects of Solution Treatment, Iron Content, and Chilling of Sand Cast Aluminum-Copper Alloy," submitted *A.F.S.*, 1958.



The potash crystallizers under construction above are two of seven that were shop- and field-fabricated, then field-assembled by welding. Although these units were not stress-relieved or heat-treated, there was no sign of stress-cracking after a year's service.

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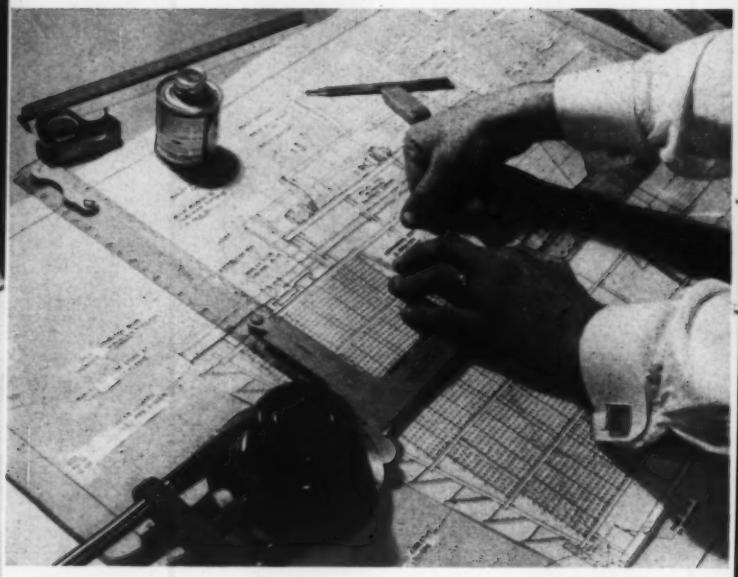


How a Kansas City manufacturer

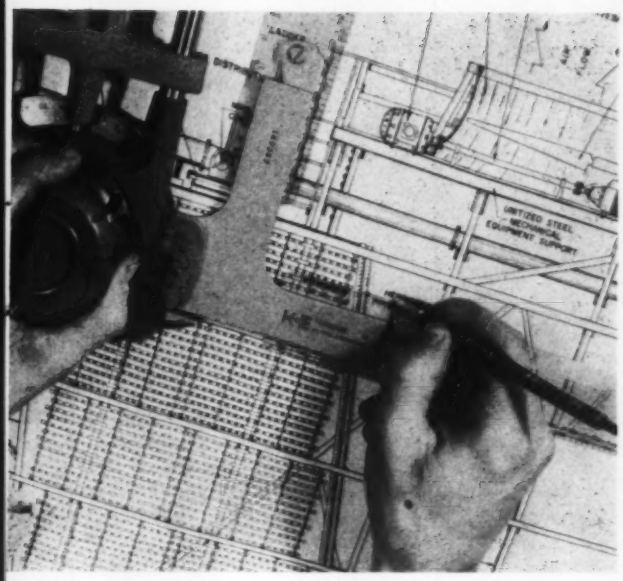
CUT $16,000 in

by using 105-mm film reproduction, offset-printed drawings, and a new "scissors drafting" technique

$16,000 IN ONE YEAR—that's the amount the Marley Co. has saved by using photographic methods in drafting. The Kansas City manufacturer of cooling towers has cut drafting costs sharply by using reduced-scale tracings and making required multiple prints on an offset press instead of full-size direct diazo positives. Another drafting short cut, dubbed "scissors drafting," promises to slice drafting time in half on certain types of drawings.

Marley has used small-size offset for many years, plus conventional blueprint and diazo processes. In 1956, the engineering department, under Lawrence Hulse, chief draftsman, decided to utilize new diazo offset plates to replace full-size prints if possible. Simplicity of mailing 8½ x 11 and 11 x 17 in. prints instead of 17 x 22 and 22 x 34 in. sheets to U. S. and foreign locations was appealing from the standpoint of packaging and mailing costs, plus ease of handling.

A 105-mm process of Micro-Master Inc. provides the link between the tracing and the plates which are actually exposed in a diazo printer. The 105-mm lab in Kansas City films the original drawings as they come off the drawing boards and blows them back up to either 8½ x 11 or 11 x 17 in. These are printed reverse reading on Keuffel & Esser Co. 404ET Photact tracing paper, which holds a razor-fine and very black line. The Photact transparencies are then exposed



Scissors Drafting

1. Film original drawing; make prints

In one cooling tower design, eight different combinations of the same basic elements were needed. One primary drawing and one set of engineering notes were prepared. The Micro-Master camera then shot one 105-mm film of the drawing and one of the notes. Eight full-size prints were made on K&E 404ET tracing paper, right side up.

2. Cut out and paste up components

The eight prints were given to two draftsmen, who chopped up the components and laid them out on regular sheets of tracing paper with printed borders and title blocks. Components were then taped down with pressure-sensitive tape or anchored with rubber cement.

3. Add lettering; make new prints

Lettering was added, the eight modified prints rephotographed on 105-mm film, and a photo-printed duplicate tracing made in full original size. Edges of pasted-up components do not show, since the process drops out these details.

Drafting Costs

Cost Comparison
Conventional vs. Scissors Drafting*

	Time (hr)
Conventional Drafting	480
8 drawings at 60 hr each	
Scissors Drafting	252
Primary drawing work	120
1 Note sheet	4
5 Paste-ups (pictures and notes) at 16 hr each	80
3 Paste-ups (notes only) at 8 hr each	24
Supplementary work on layouts	24

*Estimated; Marley 600-class towers.

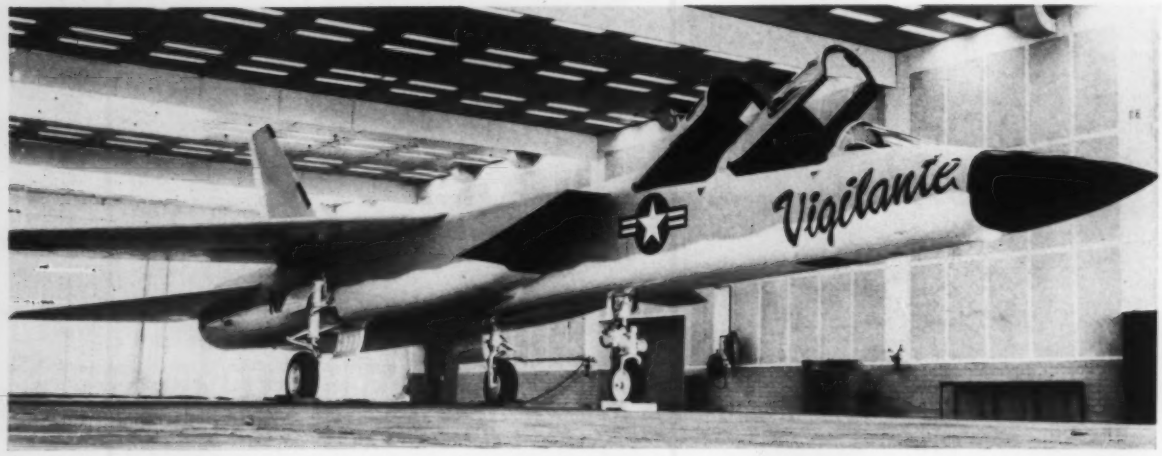
and developed with emulsion sides in contact on direct positive offset plates, and the final prints are run off on the press.

In half-size work it has been necessary to make the Photact intermediate with emulsion sides in contact to preserve maximum line sharpness. Printing through the transparency loses the line quality.

Marley's new system offers still another advantage. The same transparencies can be altered by erasing or eradication to make engineering changes, keeping the design current. The print also constitutes a photo tracing which can be used to make a single print or a few prints in case of emergency without even making a new plate. If the intermediate were a film negative it would have to be made over from the original tracing.

Another interesting by-product of the use of 105-mm is that the 4 x 6 in. films are small enough to be stored conveniently at a remote location to serve as a replacement file in case of fire or other disaster. The 105-mm film has been found capable of enlarging big tracings back to full original size, without loss of detail, on a tracing paper or cloth. With 105-mm film, maximum reduction is ten diameters.

The "scissors drafting" technique looks like it might save even more money. The method involves making one primary drawing and cutting and pasting up prints of parts of this drawing to make new originals of modified designs.



NEW NAVY FIGHTER, North American's A3J Vigilante, is being readied for first flight tests. The new all-weather attack weapon is powered by two General Electric 15,000-lb thrust J79-2 engines. Statistics are classified, but, as a benchmark, the Air Force F104A which recently set new world speed and altitude records, is powered by one J79 engine. The carrier-based Vigilante will carry a two-man crew—pilot and bombardier-navigator—plus an assortment of nuclear and conventional weapons.

Says Sea Life Shows How to Exploit Minerals

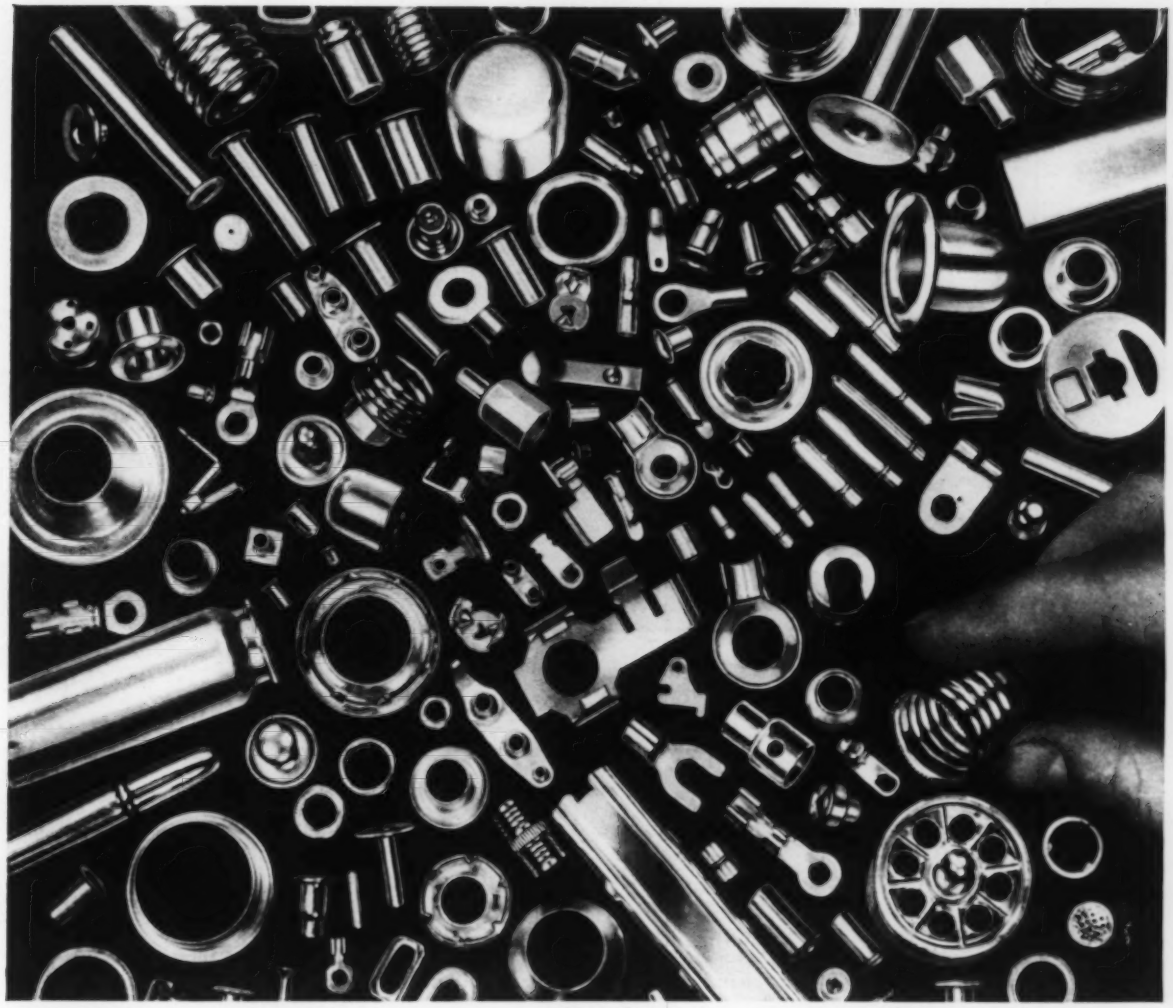
Simple Organisms Concentrate Dilute Elements from the Sea

NEW YORK — The simplest living organisms and units of matter can teach mankind how to develop a process in which the input would be sea water, and the output would consist of a dozen different, concentrated, and well-separated minerals. A great new field of useful knowledge will be opened up when we understand how elementary forms of life are able to concentrate chemical elements from such dilute sources as sea water, according to Dr. C. C. Furnas, chancellor of the University of Buffalo in a recent address before the American Iron and Steel Institute.

He described the many tasks performed by living organisms which man would like to emulate. Oysters can select one part per million of copper in sea water and concentrate it about a thousand-fold in their bodies; the sea cucumber builds up a concentration of 10 per cent vanadium in its respiratory tract; appreciable quantities of columbium are found in the flesh and blood of ascidians.

"We badly need to find out what happens in these biochemical organisms which pick one molecule out of a million and take it into their structure for their own purposes," he told the meeting. The lowly organisms could teach us, if we could only learn, he said, "how to get more and more from less and less, and to re-win all of our mineral resources from what are now considered to be completely inadequate sources of supply."

SMALL-PACKAGE EARTHMOVER, tractor-attached, performs the same jobs as heavy machines, but on a smaller scale. The Terra-Scoop, made by the Danuser Machine Co. of Fulton, Mo., slices off high places, carries dirt, dumps, levels, and scarifies, without pulling long ropes or levers. Fingertip hydraulic controls actuate all movements. It takes a half-yard of dirt in one load and can be reversed by changing four bolts.



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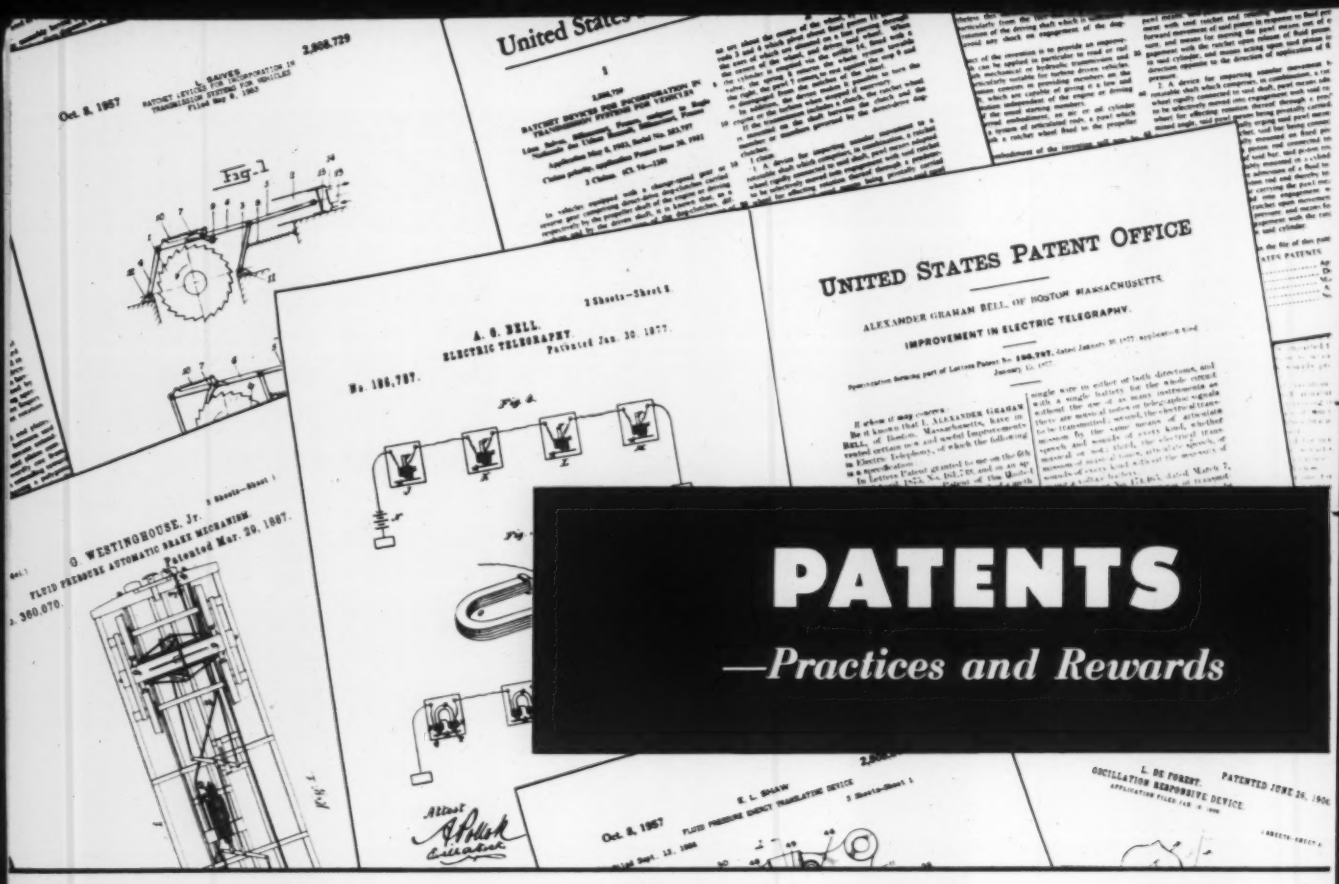


PATENTS TODAY are a far cry from what the framers of the Constitution intended. They sought to reward the inventor with a lawful monopoly on his idea for a fixed period, during which time he could exploit the idea to his own best advantage. And yet today our new and important developments stem mainly from group efforts in highly advanced laboratories. Few individuals can independently afford the equipment and manhours needed for protracted research. As a result, it has been our industrial concerns who have supplied the money and manpower to bring these new developments into being.

To protect their considerable investment, companies have felt it only natural that patentable ideas developed by employees on company time with the aid of company equipment should be assigned to them. According to the survey, *Engineering Manpower: How To Improve Its Productivity,** on which this series of articles is based, companies have sought patent assignments from their employees more for the reason of self-protection than for any desire for royalties or licensing income that might result from private ventures.

Much criticism has been leveled at the practice of requiring assignment of patent rights by technical employees as a condition of employment. Most of the criticism is based on the contention that this requirement stifles the engineer's motivation. Some critics feel that companies' increasingly stringent patent requirements have turned engineers into production-line thinkers with little opportunity for individual gain. This trend, if continued, they claim, will adversely affect our technological progress.

Patents in practice

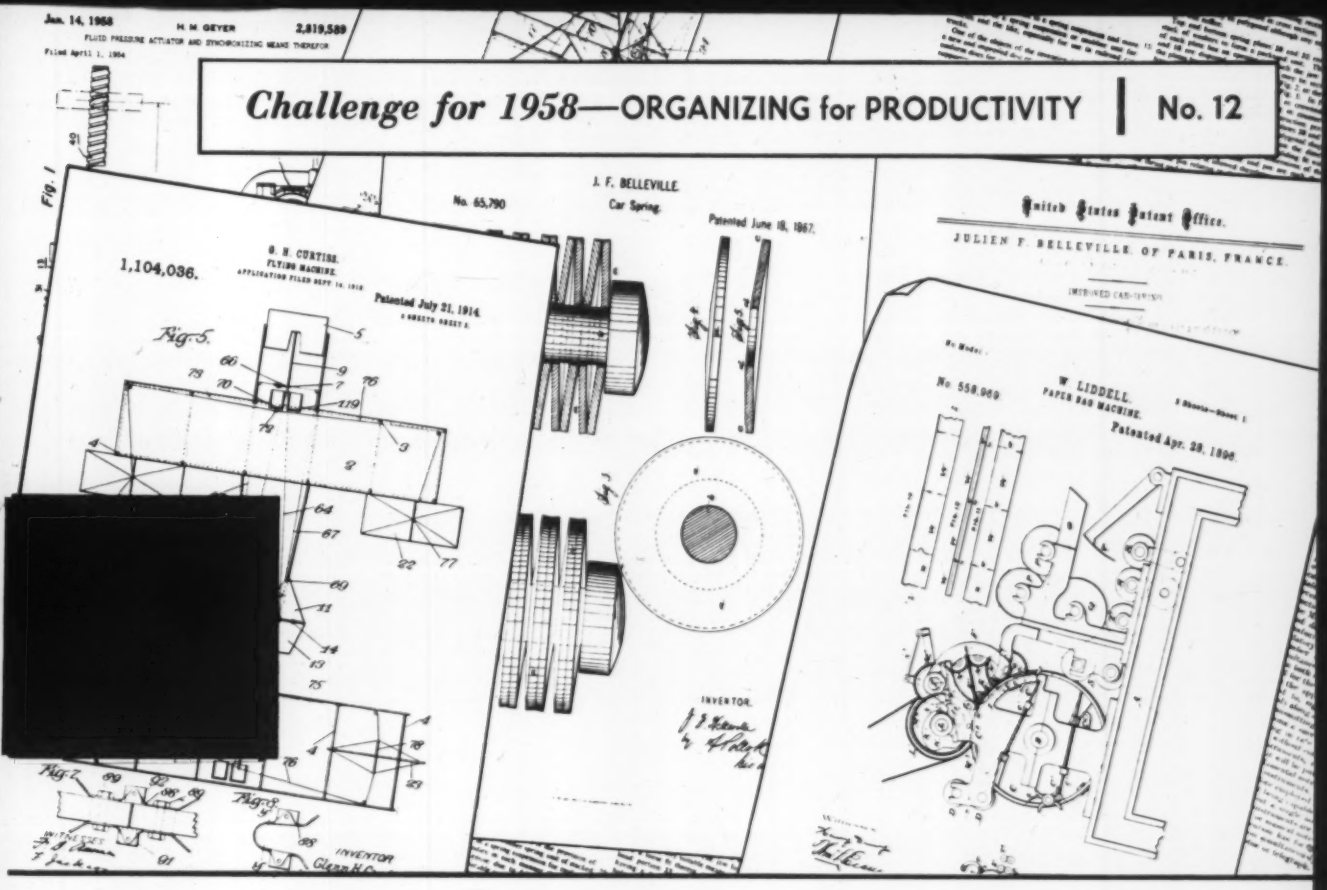
Patent assignments are usually obtained through an agreement signed by the technical employee when he starts work for a company. Most often the patent is issued in the name of the person who perfected the process or device, but the right to exploit the patent is assigned to the employer. When a group of engineers and technicians work together on various phases of a company project, the patent is often drawn up without pointing up individual contributions.

Engineers as a group have not opposed this development. Those contacted in the survey showed only slight concern over the fact that their patentable ideas became the property of their employers. The survey found that an overwhelming preponderance of the companies require their technical employees to sign an assignment agreement as a condition of employment.

But the length of time that a company controls patent assignments varies considerably. A recent study on patents reports that 65 per cent of the firms contacted maintain the assignment requirement only during the employment, while 17 per cent maintain the requirement for a period after employment ceases. Further, 75 per cent of the firms' agreements apply only to discoveries in their field of interest.

While patent assignment is usually a condition of employment, there were some notable exceptions to this pattern. Several companies said they allowed their employees complete rights to their patents in cases where the invention had no connection with the firm's product. One airframe manufacturer said

*© 1957, G. A. von Peterffy



that the company lawyer gave free legal aid to engineers who had derived ideas not of direct value to the company. An electronics firm executive endorsed this concept and said that "individually owned patents were a fairly regular occurrence." The survey noted also one small electronics firm that refused any form of patent assignment and insisted that any device patented was the property of the inventor exclusively.

The extent of patent control by industry is emphasized by the results of a recent poll of 2950 companies. Together these companies own about 233,000 patents with an additional 65,000 patents pending. Not only has the industrial control of patents increased, but a considerable concentration of patent holders among industrial firms has developed. A Senate subcommittee revealed that during the period 1939-55, 59 per cent of all patents were awarded to corporations and during this same period, a group of 176 corporations were granted more than 20 per cent of all patents issued.

Survey findings indicate the practice of requiring assignment of patent rights has not had as unfavorable an effect as some critics would indicate. Supporting the contentions of such scientific leaders as Dr. Vannevar Bush and most businessmen today, findings show that although the patent assignment unquestionably has some effect on motivation, it is by no means a prime incentive in the motivation spectrum. The recognition that may go with a patent is a more impor-

Checkpoints for Engineering Management

- ☑ **1. Does your company require patent agreements as a condition of employment?**
- ☑ **2. Does the company offer suitable recognition for patentable ideas?**
- ☑ **3. If recognition is given, do engineers take in stride the assignment of their patents to the company?**
- ☑ **4. Have you considered the company's system of awards in the light of stimulating further patentable contributions?**
- ☑ **5. Is the company itself active in deriving full benefits from the patent system?**

Recommendations for Management

1. Recognize the Contribution

Too many companies have been quick to take patent rights from engineers without replacing them with some other form of recognition. It is the recognition for the patent that is of real importance, and unless the company evolves an alternate method of rewarding the engineer, his motivation may be impaired.

2. Give Appropriate Awards

Although many companies do have extremely successful systems for paying engineers for their ideas, a system of rewards does not have to involve monetary disbursements. The essential point is—it must show the engineer that management is aware of his contribution.

3. Adopt a Method

Many companies note unusual work when it comes time to make promotions. But it is difficult under such a system for the engineer to know how much or how little a patentable idea has affected his promotion. For this reason, management is advised to adopt a specific method for recognizing patentable ideas, which the engineer will see as positive evidence that management is aware of his contributions.

4. Consider the Name

One excellent method for according recognition is the naming of the process or device after its inventor. Not only does this system convey management's appreciation to the engineer, but it also enhances his reputation among his colleagues.

tant incentive than assignment of the patent itself.

Rewards for patentable ideas

In most companies contacted, management appeared sensitive to the possibly harmful effects of patent assignment. To compensate and recognize creative employees, many corporations have evolved invention reward systems.

Though most companies require the patent agreement of their employees, methods of rewarding people for patentable ideas vary considerably. A survey of industry showed that about one-half of the firms contacted grant bonus payments of various amounts for each invention.

Some firms believe that the reward should be in the form of a token payment such as a one-dollar bill. Typifying this line of thought is the philosophy of a large manufacturing concern: "It's the recognition for the patent, not the reward that is important. A dollar bill provides just as much recognition as does a much greater sum."

However, other companies have other ideas. Many translate inventiveness into job considerations. A steel company replied: "We recognize outstanding performances through merit increases in salaries and in turn, adjustment into the management ranks." A chemical firm flatly stated, "Engineers are paid to turn up inventions and techniques." A business machine manufacturer was matter of fact: "Engineers are paid to do creative work and inventions are a result of this work."

Yet numerous companies give substantial rewards to employees who are responsible for patentable ideas. A large steel company reported, "When the patent is issued, the inventor receives $600 from the corporation unit in which he is employed. Each other corporation unit that adopts and uses his patent pays him $200. An outstanding invention is considered for a meritorious award, the amount of which relates to the importance of the invention." Similarly an airframe company said: "An inventor may receive $100 at the time the company files for patent application and an additional $500 when the patent is issued. There are further awards for inventions which are licensed to produce royalties."

One particularly rewarding method was described by an airframe company in its recruiting pamphlet: "A most lucrative patent royalty plan is offered—20 per cent of the first $100,000 in royalties, 10 per cent of the next $400,000, and 5 per cent of all amount accruing thereafter."

It should be noted that all companies, particularly those that do not give financial rewards for inventions, consider an engineer's patent record a very definite basis for salary increases and promotions. In the words of one executive:

- They are a concrete, measurable quantity, and as such are a useful guide in our periodic reviews of engineers."

Still, it was found that engineers in many of the companies which do have some form of recognition procedures seem somewhat dissatisfied. Monetary recognition is seldom what is wanted. Instead the survey disclosed a general desire for more recognition in nonmonetary areas.

Copies of the original report, *Engineering Manpower: How To Improve Its Productivity*, on which the 12-article series, "Organizing for Productivity," is based, are available for $18.50 each from: Engineering Management Reports, P. O. Box 161, Cambridge 38, Mass.

The report covers a comprehensive survey of engineers in industry. The study was conducted by a group at the Graduate School of Business Administration at Harvard University at the direction of Prof. G. F. Doriot. George A. von Peterffy was leader of the group, which included Robert E. S. Arndt, Jack L. Clark, Charles W. Coker Jr., William B. Ellis Jr., George C. Hibben, C. Bayard Johnson Jr., Silas Keehn, and Robert M. Prioleau.

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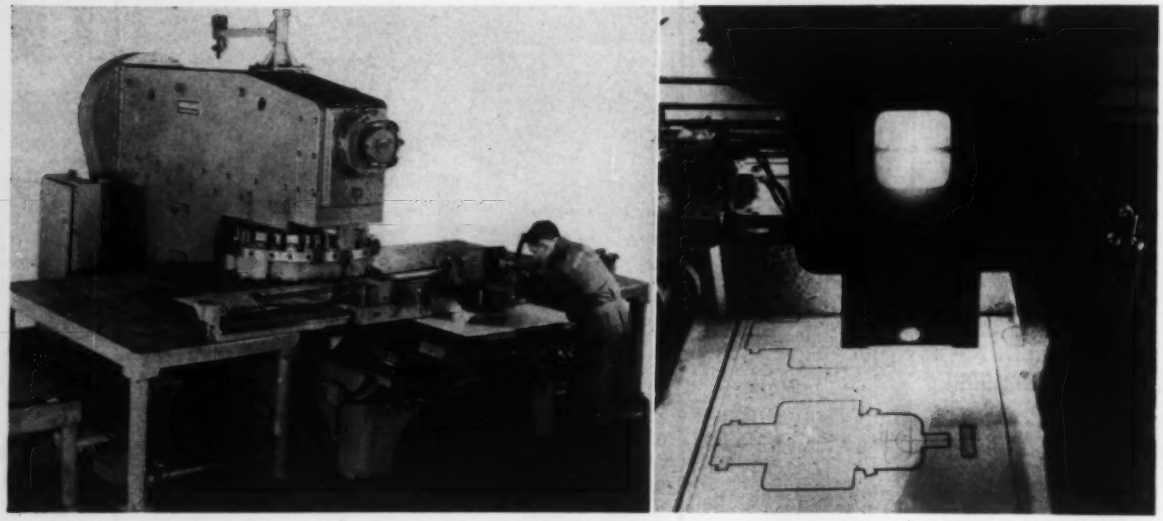


OPTICALLY SET turret punch press reduces preparation time required to fabricate panels and other parts since detailed shop drawings are not required. Only the outside dimensions of the part are required. Transparent subtemplates for each opening or group are pasted or taped onto a sheet of transparent vellum. When finished, this master drawing is photographically reproduced on a sheet of dimensionally stable paper. The sheet is then positioned and held on the vacuum table, actually becoming the template for hole locations. The punch press operator views locations on ground glass screen, which magnifies ten times. Drawing locations are reproduced to ± 0.005 in. tolerance. All punches and dies are carried on the turret.

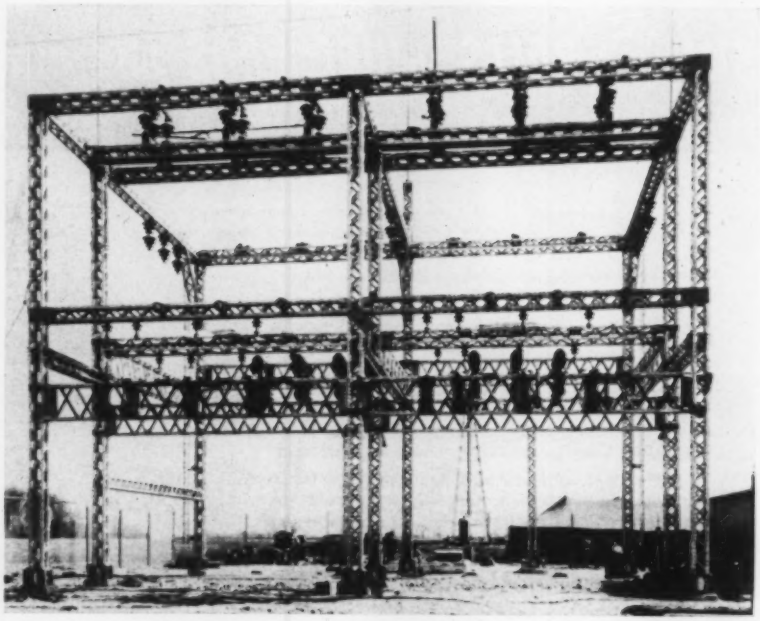
Airdrop Cargoes Cushioned by Paperboard Honeycomb Pallet

WASHINGTON — Paperboard honeycomb forms a highly effective shock absorber on a new expendable "drop kit" developed by Army Quartermaster Corps.

The new material is contained in a simple plywood framework to provide an airdrop pallet that weighs half as much and is about one-tenth as costly ($95 vs. $900) as metal-honeycomb pallets now in use.

More important than cost and weight, from an operational standpoint, use of the new material has greatly increased the accuracy of parachute drops. Paperboard has proved to be a better impact absorber than metallic honeycomb, permitting equipment and supplies to be dropped at a faster rate of descent. Drifting is thus minimized.

In use, equipment to be airdropped is secured to pallets, and cargo parachutes are attached directly to the equipment. In this manner, the pallet is not subjected to violent g-forces when the chute opens. The plywood framework permits the pallet to be moved easily and quickly over rollers or wheel conveyors on the aircraft floor.



FULL-SCALE ERECTOR SET was used in building prefabricated, all-aluminum electrical substation. It took just six hours to raise and position the various sections after they were ground assembled. The new substation design was developed by Handley-Brown Co. of Jackson, Mich. The system uses standard truss beams, fixtures, and other parts. Trusses are 1 ft square or 1 by $2\frac{1}{2}$ ft, and are available in lengths up to 60 ft. Of welded construction, they consist of four extruded aluminum chords supported by lacing. Sides and ends are precision punched with holes spaced at 3-in. intervals. The new design greatly reduces construction time. As a test of the assembly's precision, several visiting engineers intently observed positioning of the last horizontal truss to see if it would fit. It did.

TWO NEW OHMITE® RELAYS

with exclusive "Molded Module"* contact springs

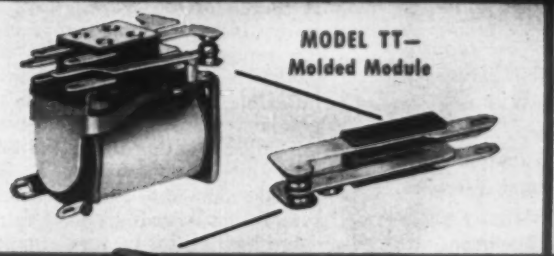
exceptional sensitivity for small size

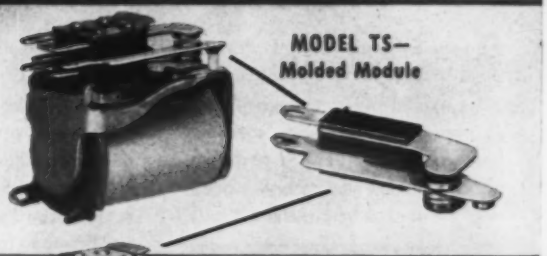
designed to meet aircraft, military, and industrial applications

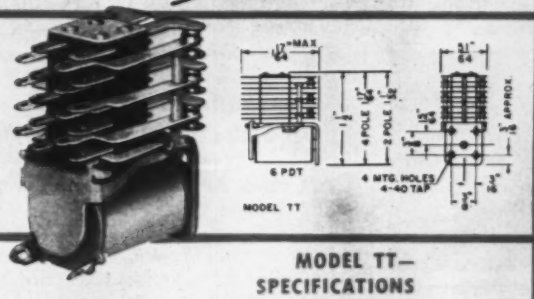
*Patent applied for

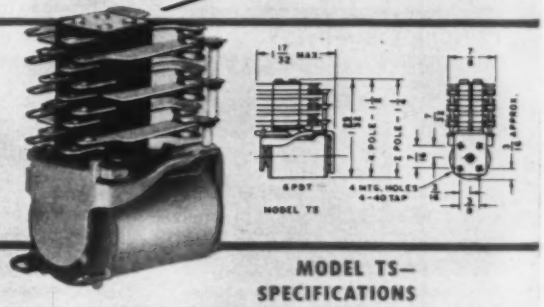
The new Models TT and TS relays incorporate several design innovations that make them ideal for aircraft and industrial applications at high ambient temperatures. Both relays are lightweight, yet rugged. Paramount among the design innovations is the revolutionary "Molded Module" contact spring construction. The "module" is a standard, single-pole, double-throw spring combination molded into a single compact assembly. As many as six modules can be incorporated into a relay to provide a maximum six-pole, double-throw combination. With the springs rigidly held in a matrix of tough plastic, alignment of the springs is assured. More accurate alignment of all the subcombinations (modules) on the relay is possible, and adjustment of the individual contact springs is easier and more permanent. Diall Phthallate, the molding material, is capable of withstanding temperatures to 400°F.

A contributing factor to the remarkable sensitivity of these relays is the design of the armature retaining guard to minimize undesirable heel gap. A wide variety of hermetically sealed enclosures is available.









MODEL TT— SPECIFICATIONS

COIL WATTAGE: Rated nominally at .150 watt per pole at an ambient temperature of 20°C.

COIL OPERATING VOLTAGE RANGE: To 115 VDC.

CONTACT RATINGS: Up to 5 amperes at 115 volts AC or 32 volts DC noninductive, with standard contact material, palladium. Other materials can be supplied.

CONTACT COMBINATIONS: Standard combinations are DPDT, 4PDT, and 6PDT (maximum). Others can be furnished.

WEIGHT: Approximately 2 ounces for 4PDT relay.

MODEL TS— SPECIFICATIONS

COIL WATTAGE: Rated nominally at .250 watt per pole at an ambient temperature of 20°C.

COIL OPERATING VOLTAGE RANGE: To 115 VDC.

CONTACT RATINGS: Up to 10 amperes at 115 volts AC or 32 volts DC noninductive with standard contact material, silver-cadmium oxide. Other materials can be supplied.

CONTACT COMBINATIONS: Standard combinations are DPDT, 4PDT, and 6PDT (maximum). Others can be furnished.

WEIGHT: Approximately 3 ounces for 4PDT relay.

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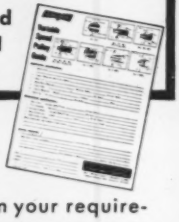

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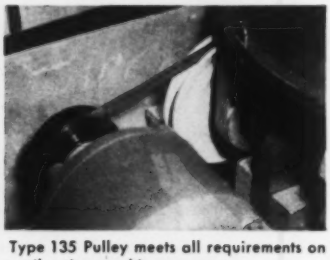
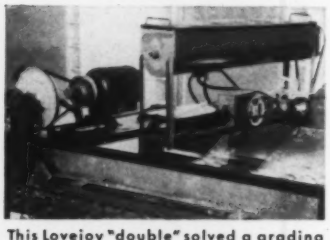
Type 160 Pulley and No. 200 Tilting Motor Base proved the right combination for a mailing machine.



Type 135 Pulley meets all requirements on a vibrating machine.

Proper drive for a slat bed rip saw is provided by a Type 302 Pulley.



This Lovejoy "double" solved a grading machine problem—Type 145 Pulley and No. 2 Select-O-Speed.

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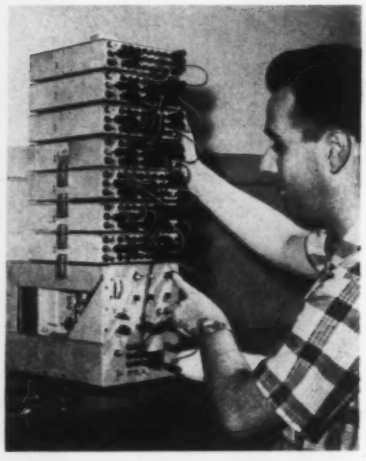

THOUSANDS OF CIRCUITS can be simulated with components of this Basic Universal Relay Programmer developed at Stanford Research Institute, Menlo Park, Calif. In many instances, the programmer can replace computer circuit pilot models which are often expensive, inflexible, not reusable. Major programmer components include timing units, counting units, and memory units that function as basic digital computer circuit elements. Plug-in patch-cords, as on telephone switchboards, easily vary simulator arrangements.

High-Performance Alloys To Shape Future Machine Tools

More Automatic Programming, Shorter Cycles Also Seen

BUFFALO—Major changes in the design of machine tools are being caused by new materials used in the structures of aircraft, spacecraft, and atomcraft. These factors, and the general trend for more accuracy, productivity, and automaticity, will dominate the future. Albert B. Albrecht, research engineer, Monarch Machine Tool Co., made these observations at the recent Twenty-Second Machine Tool Forum sponsored by Westinghouse.

According to Mr. Albrecht, trends recognized for many years have been toward "greater application of tracer-controlled lathes, higher removal rates as the result of higher cutting speeds, increased use of drives capable of constant surface speed control, machining to closer tolerances, and automation through

programming of machine tools.

"Since components for missiles and rocket motors are . . . machined from the so-called superalloys, they require substantially lower cutting speeds than those for aluminum, alloy steel, and other common engineering alloys. Average machining speeds are in the range of 100 sfpm or less, and the maximum depth of cut is often limited. Considerable design changes precede production runs; and extremely flexible equipment is needed.

In recent years, applications of such metals as zirconium, hafnium, and beryllium have increased rapidly. "We need to know more about the inherent strength of these alloys in shear, more about their frictional properties and how these properties limit the speeds and feeds which can be used in production with carbide tooling.

"In production turning it is common practice to combine operations and to eliminate a setup wherever this is practical. Considerable progress in this area has been made through the use of special slides and multiple-cut cycles. Roughing and finishing operations are accomplished in a single set using an indexing turret and dual templates. Constant surface speed control is used to advantage in improving tool life and reducing the machining time required in multiple-cut cycles. Within the turning cycle, standard rear slides are used for forming, grooving, or thread rolling operations.

"In the area of general turning, tool engineers will continue to strive for higher cutting speeds in the interest of reduced machining rates. As machining cycles are reduced, the noncutting time becomes of greater importance. Additional savings in machining costs must then be derived from faster traverse rates, multiple cycles, automatic loading, and preset tooling."

Usefulness of transfer units and tape controls is being recognized despite high initial cost. "Machine programming has become important in areas where a wide variety of similar parts are produced. In most systems coded information also controls the machine cycle, spindle speeds, feed rates, and indexing of the tool slide."

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Circle 419 on Page 19

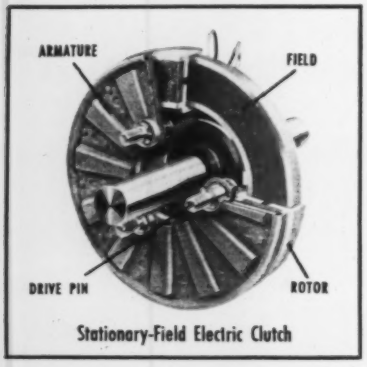
WARNER
electric motion control FACTS

for IDEA MEN

Electric motion control simplifies design of pushbutton paver

An electrical control system, made possible by versatile Warner electric brakes and clutches, not only permitted a clean, uncluttered design of the drive for this bituminous paver, but also made control of the heavy, rugged machinery a fast, fingertip operation.

Instead of the multiplicity of levers and foot pedals commonly associated with similar equipment, the operator merely manipulates fast-acting toggle switches. Benefits include easier, more automatic operation and improved work quality.



Stationary-Field Electric Clutch

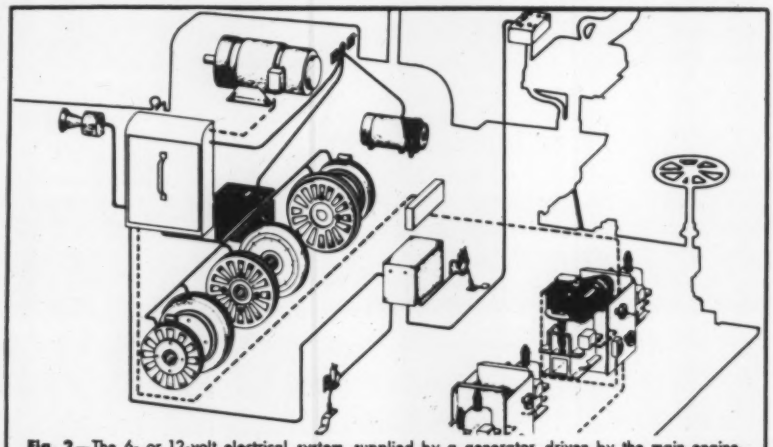


Fig. 2—The 6- or 12-volt electrical system, supplied by a generator driven by the main engine, controls the clutches and brakes for the crawlers, the slat-feed conveyors, and spreading screws. It prevents operation of the conveyors and screws in reverse gears, controls the automatic system, and powers the engine starter and lights.

Number of wearing parts reduced

Maintenance, a factor that can make or break profits on construction work, has proved to be one of the strong points of the electrically controlled machine. A complete teardown after almost a thousand hours showed nothing but normal wear on the Warner brakes and clutches.

And the new design has eliminated a number of wearing parts, such as chains, drive shafts, and universal joints. Only six chains and two V-belts are required for the power drive system, whereas other systems often require as many as 17 chains and ten V-belts.

New clutch design increases dependability

Use of the Warner Integral Horsepower design gives added assurance against maintenance cost and work delays. Slip rings and brushes are not required for the stationary fields of these clutches. Wear surfaces can be replaced without disturbing the electrical connections. Flux flows from the coil through the intermediate member, or rotor, into the armature. Thus, wear is confined to the faces of the rotor and armature, either of which can be replaced quickly and easily.

Superiority of this design is attested by the dependable, instantaneous clutching of the crawler. Steering clutches engage in approximately four milliseconds—one reason wear is considerably less than on slower acting competitive clutches. These improved Warner units can be substituted for collector-ring types with little or no design change. If you want to eliminate electrical maintenance, ask your Warner field engineer about the new powerful Integral Horsepower brakes and clutches.

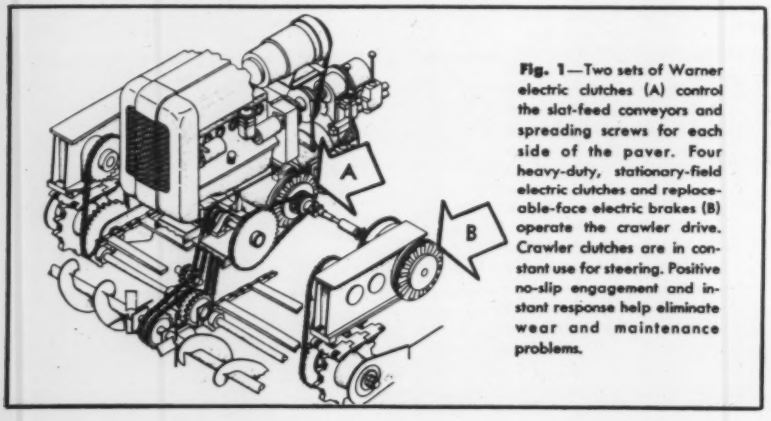


Fig. 1—Two sets of Warner electric clutches (A) control the slat-feed conveyors and spreading screws for each side of the paver. Four heavy-duty, stationary-field electric clutches and replaceable-face electric brakes (B) operate the crawler drive. Crawler clutches are in constant use for steering. Positive no-slip engagement and instant response help eliminate wear and maintenance problems.

Want more IDEAS?

Send for factual application sheets showing how machines are made more productive, easier to control, simpler to maintain with electric brakes and clutches. Write to:

Industrial Products Division
Warner Electric Brake & Clutch Co.
Beloit, Wisconsin

WARNER **ELECTRIC BRAKES AND CLUTCHES**

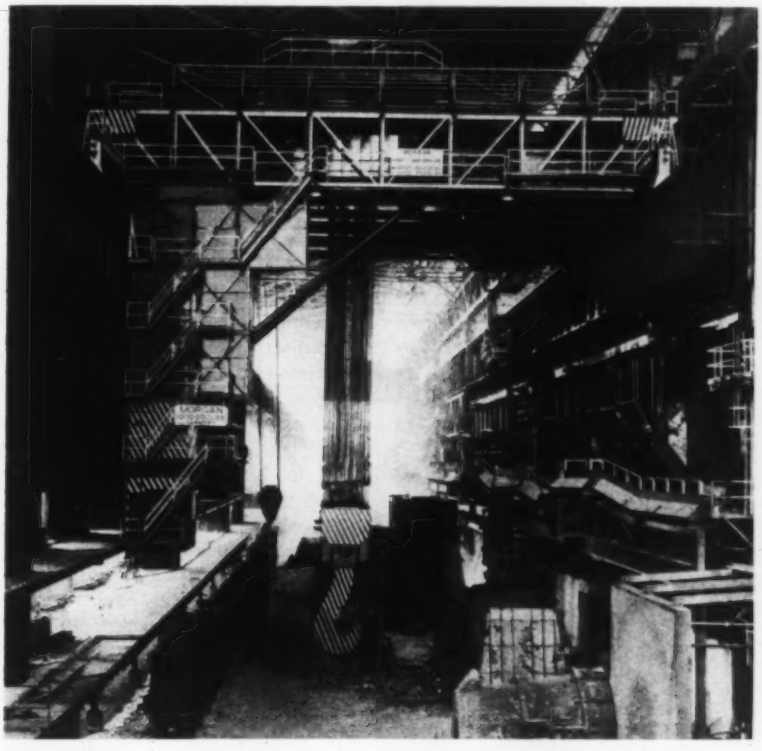
Circle 420 on Page 19

BATTERY WARMER used by the Army depends on body heat to keep batteries operative in −40 F arctic temperatures. Most dry cells normally become completely dead at −10 F. The convenient vest-carrier is more reliable and much simpler than previous warming devices that required electric heating elements.

Multicolor Films and Prints Made From Black-And-White

MOUNT PROSPECT, ILL. — Multicolor diazotype films and glossy prints are made from ordinary black and white translucent originals by using a special kit of materials in a new process. The kit enables the fast production of multicolor overlays, diagrams, charts, and projection training films.

Films or glossy prints, each containing one, two, three or numerous colors on a single sheet, are made by exposing a translucent original and a sheet of Charles Bruning Co. multicolor film or paper to any ultraviolet light source, and applying various multicolor developers to the latent printed image. No special room lighting conditions, skills, or



ONE MILLION POUNDS is the capacity of this ladle crane, claimed to be the largest ever built. The ladle is 17 ft high and will hold 375 tons of molten steel. Combined weight of the two ladle hooks is 34 tons. Bridge, spanning 77 ft, rests on four main girders which in turn are mounted on massive four-wheel trucks. Eleven electric motors, totaling 1658 hp, drive the crane at a full-load speed of 315 fpm. An auxiliary 75-ton capacity trolley is required solely to tilt the ladle. Morgan Engineering Co., Alliance, Ohio, is building three of the big cranes for an eastern steel mill.

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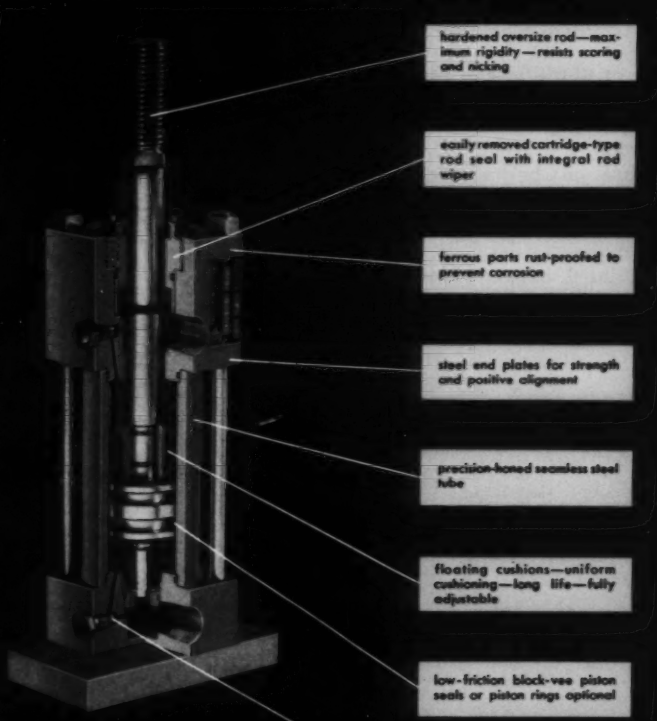
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experience are required for using the kit.

Included in the kit are double-coated films on which one original can be reproduced on one side in multicolor, and a different original on the other side. These films are said to be especially useful for making composite prints of diagrammatic drawings.

Propose Fitness Standards For Space Crew Members

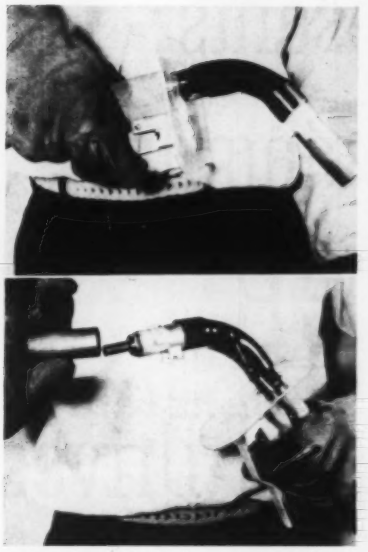
Say Space Engineer's Biggest Headache Is Man

LOS ANGELES—Man is a highly restricted organism capable of living only in limited ranges of environment, and as such, poses the engineer's biggest design headache for space vehicles. The future, and even the first, vehicles should be designed to require only the minimum adaptation on the part of man. The extent to which selection and training of space crews are problem areas indicates the less-than-optimal physical and social engineering of the space vehicle.

To date, the investigations on man's tolerance to impoverished environments have been almost entirely a descriptive process. More research is necessary to isolate the variables defining the boundaries between tolerance and psycho-physiological acceptability. These conclusions were among subjects of a paper authored by D. W. Conover and E. N. Kemp of Convair for presentation at the recently held Semiannual Meeting of the American Rocket Society.

The first crews will be self-selected. In fact, several pilots are already in preparation for the first flight. These men have a keen interest in the problems of space flight and the ability to maintain a dedicated interest in what they are doing; self-discipline that allows no room for self-doubt; and a lack of "other - mindedness." For future, long duration space voyages, the criteria will be different, and real selection and training programs will come into their own as a result of experience gained by the pioneer crews.

Circle 422 on Page 19



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The authors suggested physical factors which can serve as fine cut-off points in differentiating among space-crew candidates:

1. Typical reaction to common drugs, such as the antihistamines, tranquilizers, antibiotics, etc. They recommended this on the supposition that drugs of either a stimulating, depressing, or medical nature may be found useful as adjuncts to survival during various phases of flight.

2. Detailed tests for emotional stability. It will be necessary to make repeated tests for autonomic responsiveness and instability. Of particular concern will be onset of response, degree of disruption of ongoing behavior by sudden violent stimulation, and recovery rate.

3. Vestibular system response.

(*Please turn to Page 44*)

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Adjustable Speed Packaged Drives

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Cutler-Hammer Ultraflex Packaged Drives provide outstanding savings in installation, operation, and maintenance

MOVING PARTS!

Ultraflex Adjustable Speed Packaged Drives offer new opportunities for quick, cost-cutting installations. Light, compact static power conversion components have replaced the conventional m-g set resulting in substantial savings in size and weight. Ultraflex Packaged Drives save up to 50% in valuable floor area . . . up to 75% in weight permitting rapid installation or rearrangement of production machinery without special handling equipment or floor loading preparations. Also, Ultraflex units require no balancing or alignment attention during installation.

Ultraflex Adjustable Speed Packaged Drives provide a new high standard of operational efficiency, ultra-responsive speed control, and ultra-precise speed regulation. No special A-c power supply is required and the exclusive Ultraflex static power conversion systems guarantee greater efficiency than ever possible with conventional drives. Further, every Ultraflex Packaged Drive works perfectly without forced ventilation which means less power is consumed as unwanted heat. Also, Ultraflex Packaged Drives are noise and vibration free.

Dependable, maintenance-free performance is one of the outstanding achievements of the all new Cutler-Hammer Ultraflex Packaged Drives. With the Ultraflex static power conversion system, there are *no* bearings to lubricate or replace when worn. There are *no* commutators to service, *no* brushes to replace periodically. There are *no* shafts to align, *no* couplings to maintain, *no* inertia loads to balance. There are *no* forced ventilation fans, *no* filters to clean or change. Ultraflex circuit components are inherently rugged and trouble-free.

Cutler-Hammer Ultraflex Packaged Drives are available in two forms . . . Ultraflex E—the 1 to 40 hp, low cost electronic type adjustable speed drive and Ultraflex M—the 1 to 200 hp, ultra-efficient magnetic amplifier type adjustable speed drive. Both forms come complete with the Ultraflex control unit, heavy-duty D-c drive motor, and operator's control station. Standard Ultraflex Packaged Drives provide an 8 : 1 speed range with wider ranges available upon request. Cutler-Hammer also provides a complete engineering service which will custom-design a static powered adjustable speed packaged drive to meet your specific requirements. Write today on your company letterhead for the new descriptive bulletins EN64-Ultraflex E and EN65-Ultraflex M. CUTLER-HAMMER Inc., 1310 St. Paul Ave., Milwaukee 1, Wisconsin.

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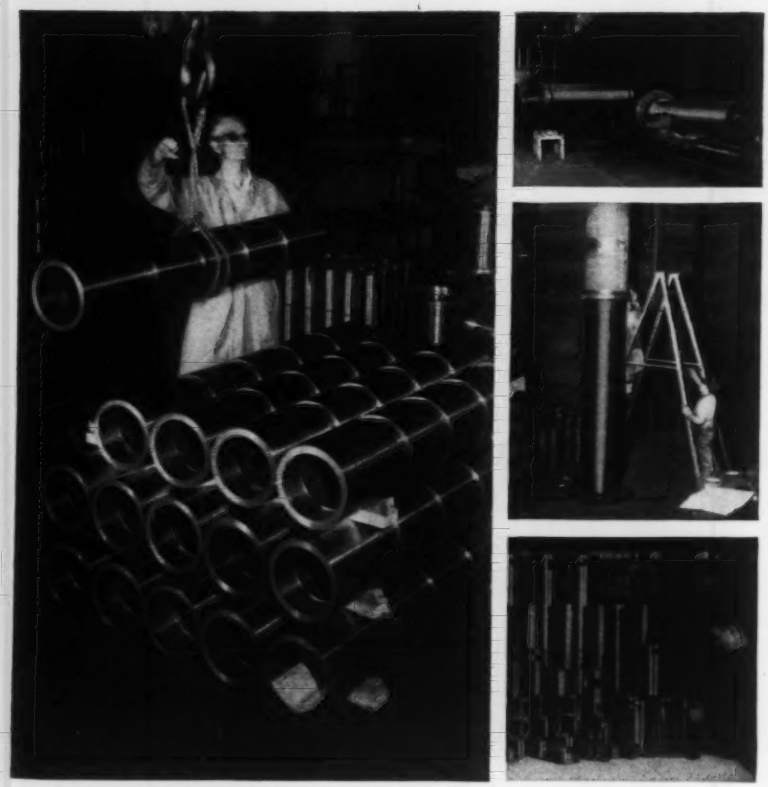

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(*Continued from Page 41*)

These measures can be made by way of the caloric test or the Barany chair. Any severe breakdown in the performance or intense emotional response to the coriolis phenomenon (a component of tangential acceleration) would constitute grounds for fine-grained selection.

4. Air pressure response. A series of exposures to sudden decompressions and recompressions are given with special reference to peculiar responses in auditory sensitivity.

5. Because of the relationship between intraocular pressure and time separating blackout and unconsciousness during high exposure, it will be desirable to employ tonometer measures for variation in this factor.

6. G-tolerance runs. This will involve actual exposures of each candidate to a wide spectrum of g-forces, durations, and directions. Complete records of the physiological and behavioral reactions will be obtained.

7. Thermal reactions. Detailed examination of the candidates' responses to temperature extremes will constitute this phase of the selection process.

According to the authors, the usefulness of these suggested criteria will depend on aeromedical research, but those mentioned appear to provide some prior starting points in the development of an advanced assignment medical form.

Meetings

AND EXPOSITIONS

June 22-25—

American Society of Agricultural Engineers. Annual Meeting to be held at the University of California, Santa Barbara, Calif. Further information can be obtained from society headquarters, 420 Main St., St. Joseph, Mich.

June 22-27—

American Institute of Electrical Engineers. Summer General Meet-

ing to be held at the Statler Hotel, Buffalo. Additional information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

June 22-27—

American Society for Testing Materials. 61st Annual Meeting and Exhibit to be held at the Statler and Sheraton Plaza Hotels, Boston. Additional information can be obtained from ASTM headquarters, 1916 Race St., Philadelphia 3, Pa.

June 23-25—

American Society of Refrigerating Engineers — American Society of Heating and Air Conditioning Engineers joint meeting to be held in Minneapolis. It will be the 54th Annual Meeting of ASRE, whose headquarters will be at the Leamington Hotel. ASHAE will hold a semiannual meeting, with headquarters at the Nicollet Hotel. Separate technical sessions and forums will be held, as well as several joint conferences. Further information is available from ASRE headquarters, 234 Fifth Ave., New York 1, N. Y.

June 23-25—

Investment Casting Institute. Annual Technical Session to be held in Muskegon, Mich. Further information can be obtained from institute headquarters, 27 E. Monroe, Chicago 3, Ill.

July 8-11—

Institute of the Aeronautical Sciences. National Summer Meeting to be held at the Ambassador Hotel, Los Angeles. Additional information is available from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

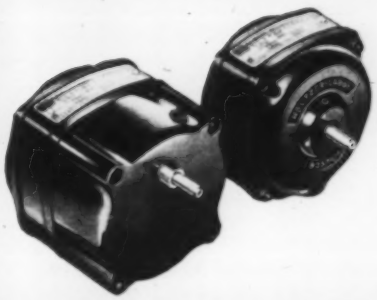
Aug. 13-15—

Conference on Electronic Standards and Measurements to be held at the National Bureau of Standards' Boulder, Colo., laboratories. Sponsors are the American Institute of Electrical Engineers, the Institute of Radio Engineers, and the NBS. Further information is available from U. S. Dept. of Commerce, National Bureau of Standards, Washington 25, D. C.

New Designs in Motors from HOLTZER-CABOT

VARIABLE SPEED SUB-FRACTIONAL DC MOTOR

This new motor—Model RBD-25—is available in two standard units: RBD-2505 with a rating of 0.5 oz. inches; and RBD-2510, rating 01.0 oz. inches. Both operate at speeds up to 1800 RPM with input of 24 to 115 V. D. C. This is a shunt wound motor and speed can be varied by changing armature voltage.



2-SPEED REVERSIBLE SUB-FRACTIONAL AC MOTOR

Model RBC-2514. Available with basic speeds of 1800 RPM and 3600 RPM and with standard gear reductions from 3:1 to 3600:1. Basic torque ratings for continuous duty at 115 volts, 60-cycles; 3600 RPM synchronous range from 0.15 to 0.5 oz. inches.

SYSTEMS DEVELOPMENT MOTOR KIT

Designed primarily for research laboratories and engineering departments, this kit makes it possible to determine the proper servo, torque or synchronous motor required for instrumentation and automation applications. Eliminates the need for purchasing sample motors for testing. Contains all the necessary motors and components to assemble—with bench tools only—32 different motors.

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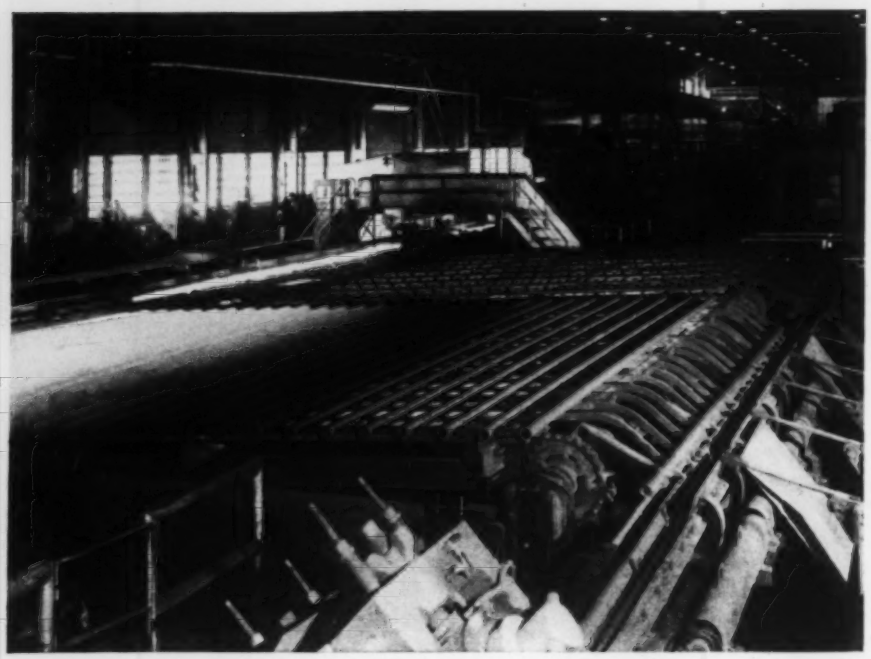
Circle 426 on Page 19

Many industrial operations need the extra qualities of Promal chain



LINK-BELT H CLASS PINTLE CHAIN with pusher attachments on this pipe cooling rack designed by Aetna-Standard Engineering Co. receives white-hot pipe from finishing operations in a continuous butt weld mill. Controlled chain speed permits uniform cooling of outer tube periphery.

Specially heat-treated malleable iron resists heavy and abrasive loads

Fewer conveyor shutdowns and minimized replacements are economies realized by users of Link-Belt Promal chain. Promal will withstand repeated cyclic heating up to 1000° F. Its greater strength absorbs continuous impact loads — and wear resistance supplies the durability to cope with severe abrasion.

A Link-Belt Development

Promal is more than a partially annealed or surface-hardened malleable iron. Developed by Link-Belt, this specially heat-treated malleable iron is actually transformed into a metal of radically different physical properties. Promal, because of uniform microstructure throughout its whole section, provides greater ultimate strength, higher yield point, exceptional fatigue resistance.

Where and how to apply Promal

Choose Link-Belt Promal chains for highly abrasive or heat-conditions — for extra strength and wear resistance demanded by heavy loads or long sliding conveyors. They last much longer . . . cost but a little more.

The wide range of Link-Belt chains available in Promal includes all types of cast and combination chains.

SMGL-618 PROMAL chain conveyor is another example of the applicability of heat-resistant Promal. This chain conveyor with special joint design and riser attachments picks up and conveys sheet steel through furnace. Chain has operated continuously for two years without failure. The heat-resistant properties of Promal also make it a desirable material for use on low-temperature heat-treating equipment.

PHYSICAL PROPERTIES OF PROMAL

Compare this with other ferrous materials used for chain applications.

Yield Point	55,000 pounds per sq. in.
Ultimate Strength	75,000 pounds per sq. in.
Fatigue Strength	35,000 pounds per sq. in.
Elongation	10 to 14% in 2 inches
Average Brinell Hardness	170 to 190

PROMAL'S high strength factors make it ideal for especially long elevators and conveyors.

HEADQUARTERS for chains, sprockets and other Link-Belt products is your nearby Link-Belt office. Refer to the yellow pages of your local phone directory.

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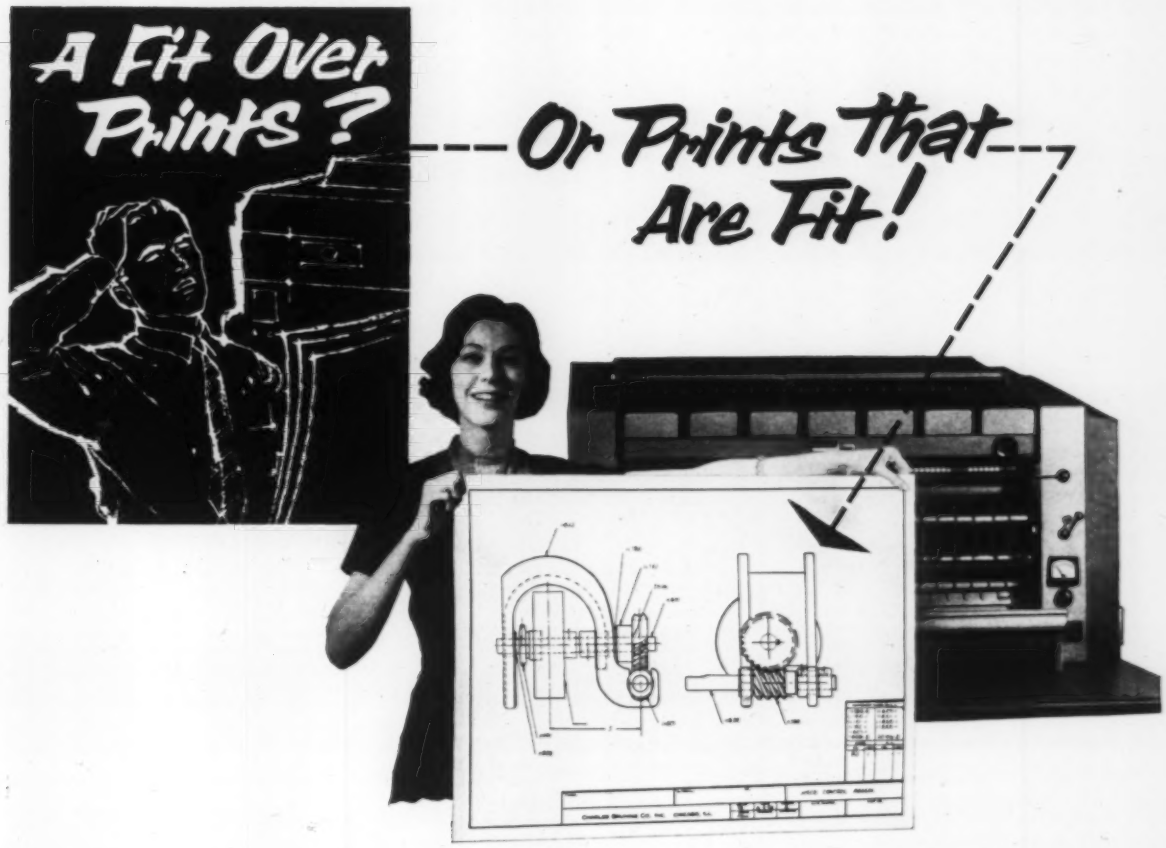

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New, advanced Copyflex models bring you faster reproduction speeds, up to 75 f.p.m., with printing widths up to a full 46 inches. They offer faster return of originals, syncronized exposure and development, automatic separation, automatic stacking, front or rear print delivery. They provide the famous problem-free installation and operation of Copyflex—no exhaust venting, no auxiliary equipment.

Copyflex machines are backed by over 100 varieties of sensitized and non-sensitized papers, cloths, and films. Sensitized materials are coated in Bruning's own plants, are made to work with Copyflex machines to give you faster, better, more versatile reproduction. They include the famous Copyflex intermediates that can save you up to 90% in tracing time in re-working originals.

Can you really afford not to investigate Copyflex? Mail the coupon below.

Send for Your **FREE** copy!

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1800 Central Road, Mount Prospect, Ill.
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Please send me the booklet on the Copyflex process, machines, and materials.

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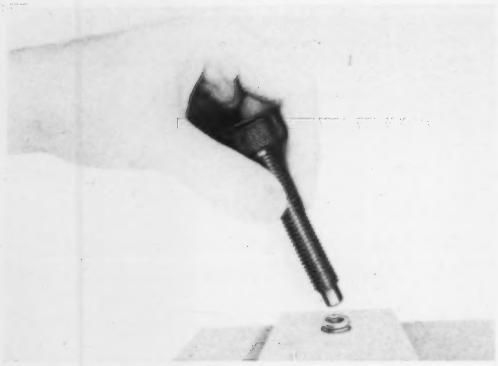
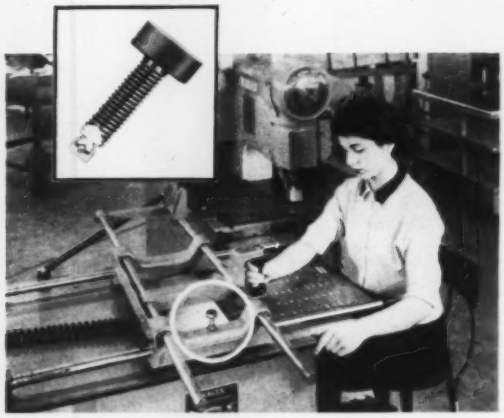
Practical Design Tips

No. 3 of a series

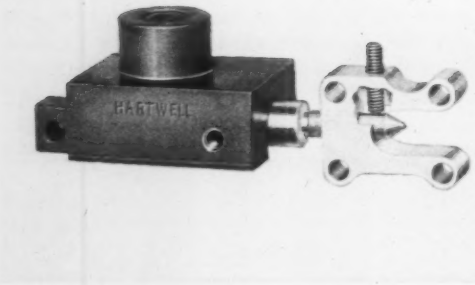
Perhaps the applications shown below will suggest ways you can profit from the use of Vlier tools. Many companies have simplified product design—with resultant savings—by substituting these simple, off-the-shelf items for complicated custom devices.



TO LIMIT TORQUE APPLIED TO SOCKET SET SCREWS grind the screw end of a Vlier Torque Thumb Screw to the proper size hex. The amount of torque can be quickly adjusted between 10 lbs. and 125 lbs. Once set torque is reached, knurled ring spins freely, preventing overtightening. Backing off is positive.



TO SECURE THE DUPLICATOR CARRIAGE of this metal fabricating machine when not in use, the manufacturer uses two Vlier Swivel-Pad Torque Thumb Screws. These simple holding tools with the unique ball-joint pad construction, limit the amount of torque which can be applied, and prevent scoring or damage to the ways. Vlier Swivel-Pad Torque Thumb Screws such as used in this application are available in various sizes and end pressures.

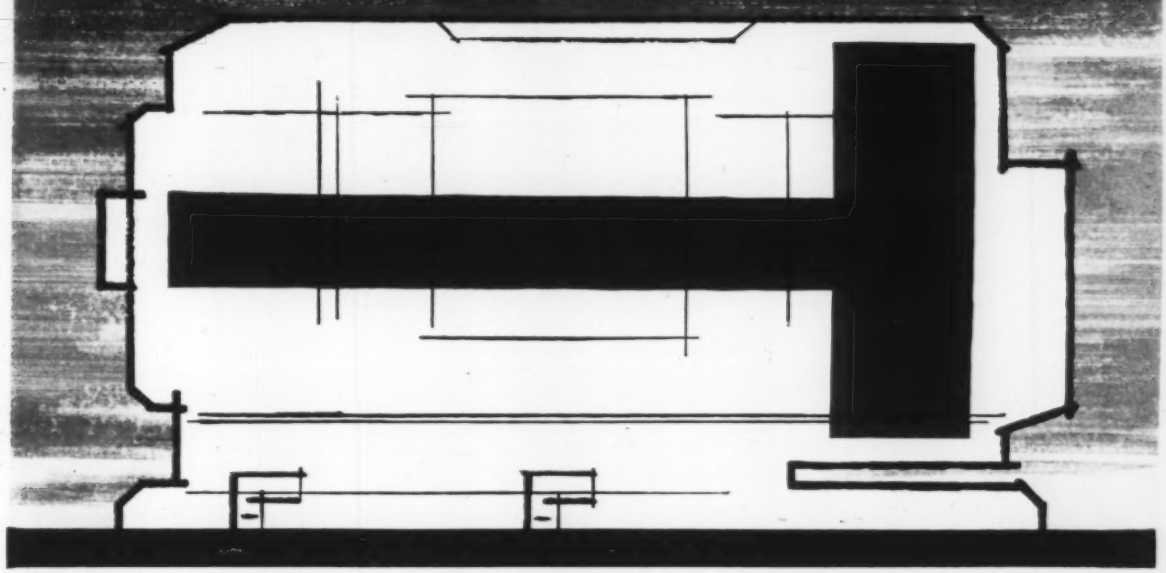


TO PROPERLY POSITION THIS YOKE-SHAPED PART for entrance into a latch assembly, a Vlier S-58 Spring Plunger is used. The threaded stud, extending horizontally, is slotted on two sides. As the stud is rotated, the spring plunger snaps into the slot assuring the proper position of the yoke. Vlier Spring Plungers are available in six nose types; various end pressures.

NEW 1958 CATALOG NOW AVAILABLE—Eight pages; completely revised. Includes information and specifications on all new Vlier products, including the Torque Handle, Stock Pusher, Leveling Pad. Makes ordering easy. Suggests new uses for these proven time-savers. Write for your copy today!

VLIER
Engineering Corporation
A subsidiary of Barry Controls, Inc.
8900 Santa Monica Blvd. • Los Angeles 46, California

How billion-proved VALFORGINGS will help an alert pump manufacturer cut part costs 19%



By making a one-piece rotor and drive shaft from a single VALFORGING, a manufacturer of pumps will be able to reduce his cost per pump more than 26 cents a unit.

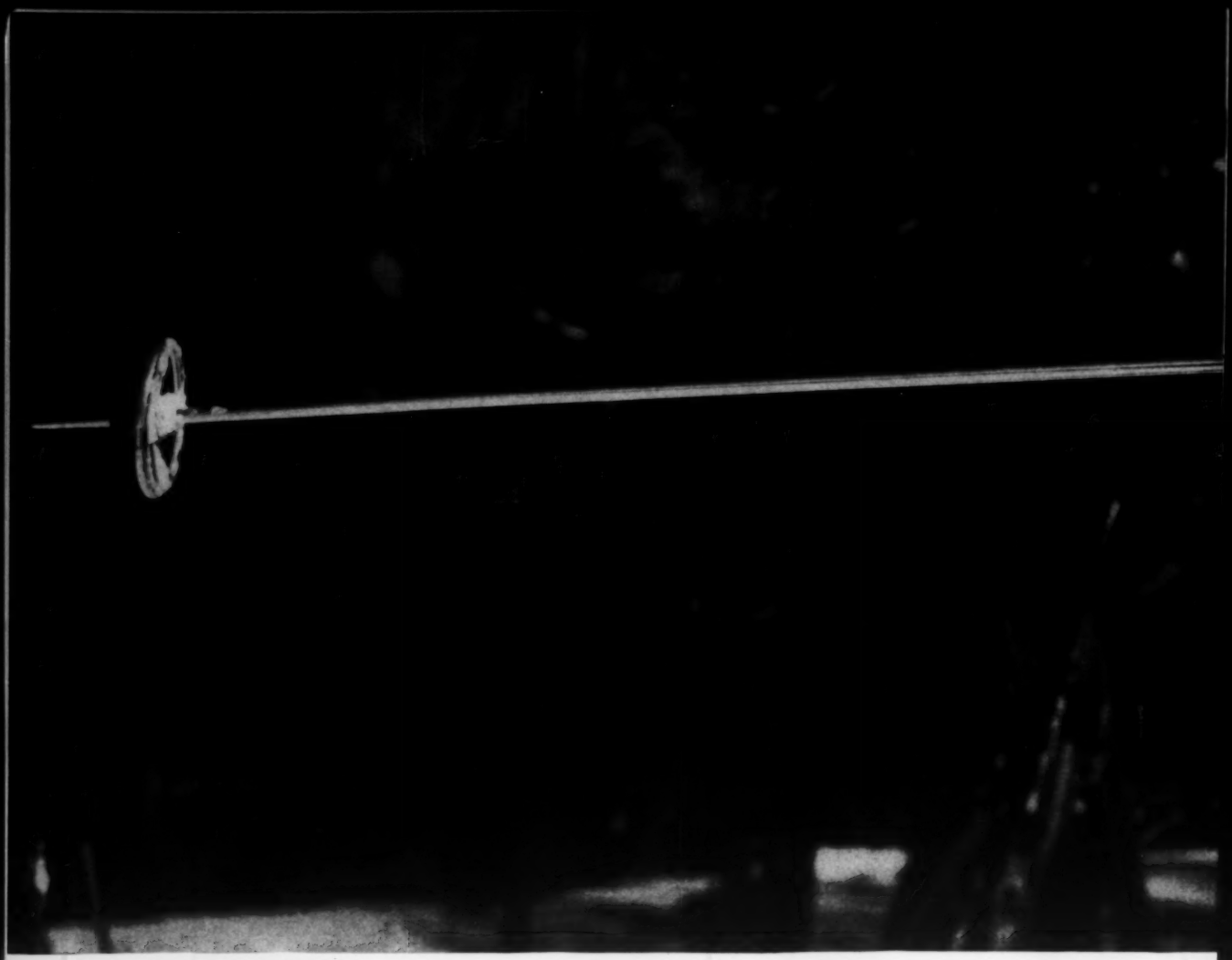
A Thompson VALFORGING is a hot-extruded steel forging whose head-to-shaft-diameter ratio is at least 1½ . . . a large head on a smaller shaft. Continuous grain flow at the neck provides higher strength at high stress points. Simple head features can also be coin-pressed into VALFORGINGS to eliminate several costly machining operations.

If you now make parts of this type by turning down overlarge rough forgings or expensive bar stock, you are generating high-cost scrap on high-burden machines with high-priced machinists. A VALFORGING comes to you forged to shape in any grade of steel you require.

Let us show you how VALFORGINGS can be made in sizes up to 5" in head diameter, 12" shaft length. Write to the address below.

Valve Division ***Thompson Products, Inc.***

DEPT. MD-658 • 1455 EAST 185th STREET • CLEVELAND 10, OHIO ©1958



Lightness—There are a few products in this world that you don't want to be light—like pile drivers, dumbbells and paper weights. But generally speaking, every designer strives for the lightest product that will do the job, especially in things like truck trailers and off-highway earthmoving equipment (the lighter the unit, the greater the load capacity) and in structures like a bridge, which has to support itself *and* a roadbed.

Lightness is easy to attain. For instance, you could make a ski pole out of balsa wood, rather than the Stainless shown above, and never know you were holding it. But almost always as we strive for lightness, we also demand a certain amount of stiffness, ductility, strength. More than that, we need a material that can be fabricated on high-speed machinery.

So it's interesting to note that today, in cases where lightness is absolutely vital and *hang the cost*, designers still turn to steel rather than costlier materials when they need low weight and high performance.

When our Explorer I satellite screamed into outer space, it was cased in Stainless Steel. On every high-performance aircraft, the landing gear is made from ultra-strong steel because each single pound shaved from the landing gear assembly saves from 7 to 10 pounds of total aircraft weight, since it reduces the wing area, thrust and fuel required for the specified performance. Today, as we prepare for the first exospheric manned flight, we are completely sheathing the fuselage in steel, because no other available material has a better combination of lightness and high temperature strength.

In new, light-weight bridges, designers automatically think in terms of the new alloy and high strength steels. They're so strong that thinner, lighter sections can be used, and they have the extra atmospheric corrosion resistance necessary.

The new steels should be chosen and fabricated with care, and the final selection should be made by a skilled metallurgist—either on your staff or ours. United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

United States Steel Corporation • American Steel & Wire • Columbia-Geneva Steel • National Tube
Tennessee Coal & Iron • United States Steel Supply • United States Steel Export Company

USS **United States Steel**

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

STEELS FOR DESIGN

Lower Left—Problem: Design a trailer to haul more coal and stay within the legal highway weight limit. Solution: Marion Metal Products Company used USS COR-TEN High-Strength Low-Alloy Steel to build a bigger trailer that is lighter because the stronger steel can be used in thinner sections. Payoff: The new units weigh 23% less than the old, have a 50% greater payload, and gross weight is *still* within the legal limit.

Lower Middle—Problem: Build a 40-ton-capacity bottom dump trailer that would have the highest payload-to-weight ratio ever obtained. Solution: Athey Products Corporation designed the unit with USS "T-1" Constructional Alloy Steel which combines a minimum yield strength of 100,000 psi with weldability and remarkable toughness. Payoff: New trailer weighs 11,000 pounds less than conventional construction and hauls payload over 3½ times its own weight.

Lower Right—Problem: Replace 550-bbl. fermentation tanks with new tanks of same capacity but light enough to hang from the ceiling. Solution: Chicago Steel Tank chose Type 304 Stainless Steel and a unique new design utilizing Stainless Steel's strength and formability. Payoff: New tanks weigh only one-fourth as much as the old and have identical capacity.

USS, COR-TEN and "T-1" are registered trademarks

white glove inspection keeps industry "on the ball"

When a ball is made of the finest of metal, and amazingly round, smooth and accurate, it deserves the last word in final inspection—the white glove treatment. That's why *every ball* produced by Hoover is given complete visual examination by trained specialists. Requirements are so exacting that the operation is carried out under scientific lighting in temperature and humidity controlled rooms. Inspectors must wear special lint-free gloves—*white ones.*

Hoover produces a complete range of standard sizes and grades of *Micro-Velvet* Balls in chrome steel, stainless steel, brass, bronze and monel, as well as commercial-type carbon steel balls. Facilities are so extensive that millions of balls are produced in a single month . . . your assurance of quick deliveries and competitive prices in addition to dependably uniform ball quality that is unmatched anywhere.

Make Hoover *your* one source for quality balls.

Micro-Velvet is a Hoover Trademark

hoover quality balls

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Title_____

Company_____

Address_____

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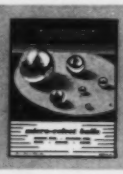


Hoover Ball and Bearing Company, Ann Arbor, Mich.

Please send the following new literature:

☐ Bulletin 101 describing Hoover *Micro-Velvet* Balls of chrome steel, stainless steel, brass, bronze, monel.

☐ Bulletin 102 describing Hoover Commercial-Type Carbon Steel Balls.

MD-6

Circle 432 on Page 19

Circle 433 on Page 19→

Years ahead G-E Form G motors designed to...

Since these motors were first introduced they have been the key to new design ideas . . . ideas to improve products, cut costs, and simplify assembly and production procedures. They can do the same for you!

MATCH YOUR PRODUCT DESIGN IDEAS

GENERAL ELECTRIC

Here's Proof

DESIGN IMPROVEMENT

With General Electric Form G Motors

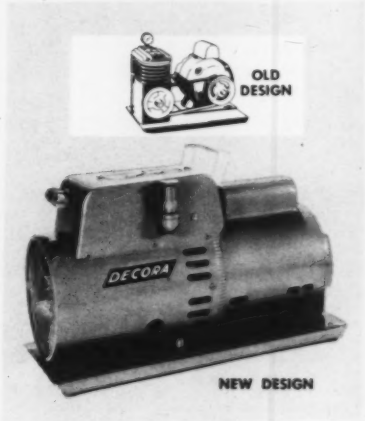
Decora Manufacturing Company

G-E MOTOR CUT PRODUCT WEIGHT 33%

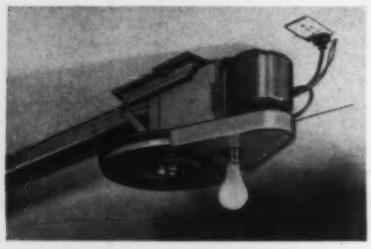
Decora Manufacturing Company set out to design a new portable compressor . . . lighter and more compact . . . intended to deliver a good volume of high pressure air.

The General Electric Form G ¾ hp motor was a natural—it required 40% less space, weighed only half as much as the motor they were using, and made possible the new model compressor.

Today, weight of the new compressor is down 30 pounds. Shipping costs are down an average of $1.50 per unit. The sleek modern lines of Decora's compressor make it look better and sell faster.



Barber-Colman, OVERdoors and Operators Division



STANDARD G-E MOTOR FEATURES CUT COST 12%

General Electric's Form G motor helped Barber-Colman realize a 12% savings in manufacturing costs. And standard, no-extra-cost features did it . . . G.E.'s all-angle sleeve bearing design and the removable cradle base.

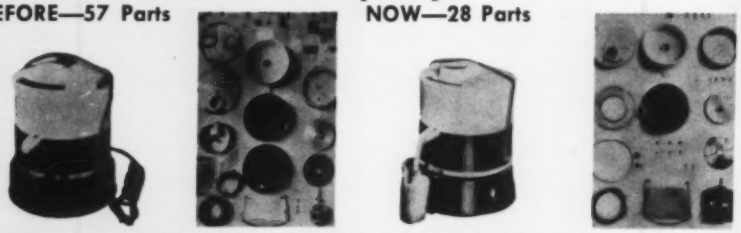
Tests proved that the G-E motor could be mounted shaft-down without sacrificing lubricating or performance qualities, thanks to G.E.'s all-angle sleeve bearing. This saved Barber-Colman the *extra* expense of ball-bearing motors for this application.

An extra benefit: In previous Barcol Automatic Door Operators, two heavy expensive mounting brackets to hold the motor had to be manufactured and assembled. In today's design, the G-E motor's removable base is spot-welded directly to the operator frame, cutting over-all product weight and saving on assembly time.

In all, these advantages meant a *definite product improvement at a 12% cost reduction.*

Sweden Freezer Company

BEFORE—57 Parts **NOW—28 Parts**

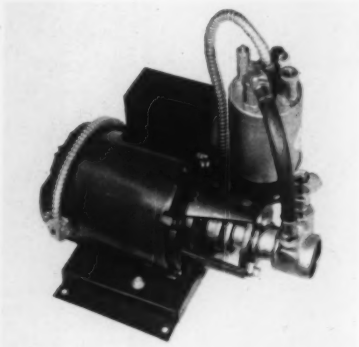


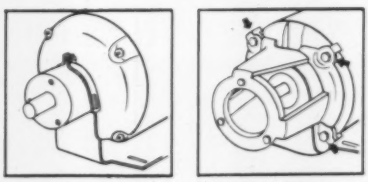
FEWER PARTS REDUCE ASSEMBLY TIME 63%

The photographs above help to show the *design simplification* which the G-E motor made possible in the new Sweden Speed Juicer. Results:
Reduced number of parts 50%, from 57 to 28 pieces.

Nearly doubled production with a minimum increase in payroll.
Cut installation time 63% over the previous method.
Made product more compact, more attractive, more dependable.

Temprite Products Corp.





ELIMINATED COSTLY MACHINING OPERATION

A standard General Electric fhp motor enabled Temprite Products to cut manufacturing costs and simplify the design of their "Bantam 100" carbonator pump.

Temprite was using another manufacturer's special motor with an integral pump mounting. The close tolerances found on *all* standard Form G motors made it possible for them to eliminate the costly special motors.

Reason: Close tolerances let them switch to an open, lightweight bracket designed by a leading pump manufacturer to fit G.E.'s standard endshield.

No special machining was required because every G-E fhp motor is designed and manufactured to these rigid specifications:

- Each boss face (shown in "new design" above) is cast to 0.01 inch wabble relative to the bearing bore.
- Outside diameter of the pulley endshield is held to 0.004 in. tolerance and 0.004/.005 in. on eccentricity.

Results: Elimination of added cost of special motors, a weight reduction of *over 50%,* and a more compact, lower cost pump.

IDEAS

Red Devil Tools

650 SHAKES PER MINUTE

General Electric Form G motors are built to take it . . . and here's proof! This Red Devil paint conditioner operates at the rate of 650 shakes per minute, a severe test for any motor.

Red Devil engineers looked long and hard for the right motor. They required small size. Bearings had to be extra rugged. Insulation had to be able to shrug off vibration. Windings had to be bonded to stay. A breakdown in any of these components would cause motor failure and reflect on the quality of their machine.

General Electric's *standard* Form G motor matched the extra-high quality Red Devil demanded. Engineers from G.E.'s General Purpose Motor Department helped in applying the right motor, made many test runs, and offered free engineering assistance both in the factory and at the Red Devil plant. The result: a high quality, truly *dependable* machine.

An extra benefit: Red Devil's customers, like most machine buyers, prefer General Electric motors . . . and there's a General Electric small motor service station in every part of the country ready to give fast, emergency service.

A full line of General Electric years ahead fhp motors is available in the ratings you need

General Electric offers you prompt delivery on more than 850 basic models. You can choose the right motor for your product without buying costly "specials."

GENERAL ELECTRIC'S ENGINEERS WILL HELP YOU WITH *YOUR* PRODUCT REDESIGN PROGRAM

General Electric's sales engineers are ready to help you lower costs, increase the power of your product, or improve its design. Years of experience have taught them many "tricks of the trade" which can help you meet your product requirements at lower cost.

Just call your General Electric Apparatus Sales Office. An experienced sales engineer will call as soon as possible. And, if your problem is especially tough, factory application engineers will be called in, too!

Why not start a redesign program of your product's drive system today? Call now to find out how you can improve your product . . . at a savings! General Electric Company, Section 702-68, Schenectady 5, N. Y.

OPERATION upturn
Buy now for extra values
GENERAL ELECTRIC

Progress Is Our Most Important Product

GENERAL ELECTRIC

Tubexperience in action

"They use this Super Alloy tubing in missiles, rockets and jets

—so you know it can lick your heat and corrosion problems!"

*"It's made by Superior Tube in your choice of 16 different materials. Believe me, this tubing can take the severest conditions of heat, corrosion and oxidation. Has very high fatigue and creep strength even at temperatures over 1000°F."

If you have a temperature and corrosion problem that causes failure no matter what type of tubing you have tried, get your Superior distributor to order Super Alloy tubing for you—it is the tubing for virtually every critical application of this nature.

Super Alloy tubing offers the important properties mentioned above, plus the dependability and longer service life built into it by Superior skills and experience. We will put your tubing through many special examinations if you want us to—eddy current and ultrasonic, hydrostatic, and hot tensile tests, stress rupture tests, qualitative and quantitative analysis, and many others—for your complete assurance in its ability to perform as required.

Our continuing test program on Super Alloy tubing has amassed much useful information on mechanical properties. You will want to make a study of them and their potential for use in your applications. They are covered in our Bulletin 70. Send for copies. Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

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The big name in small tubing

NORRISTOWN, PA.

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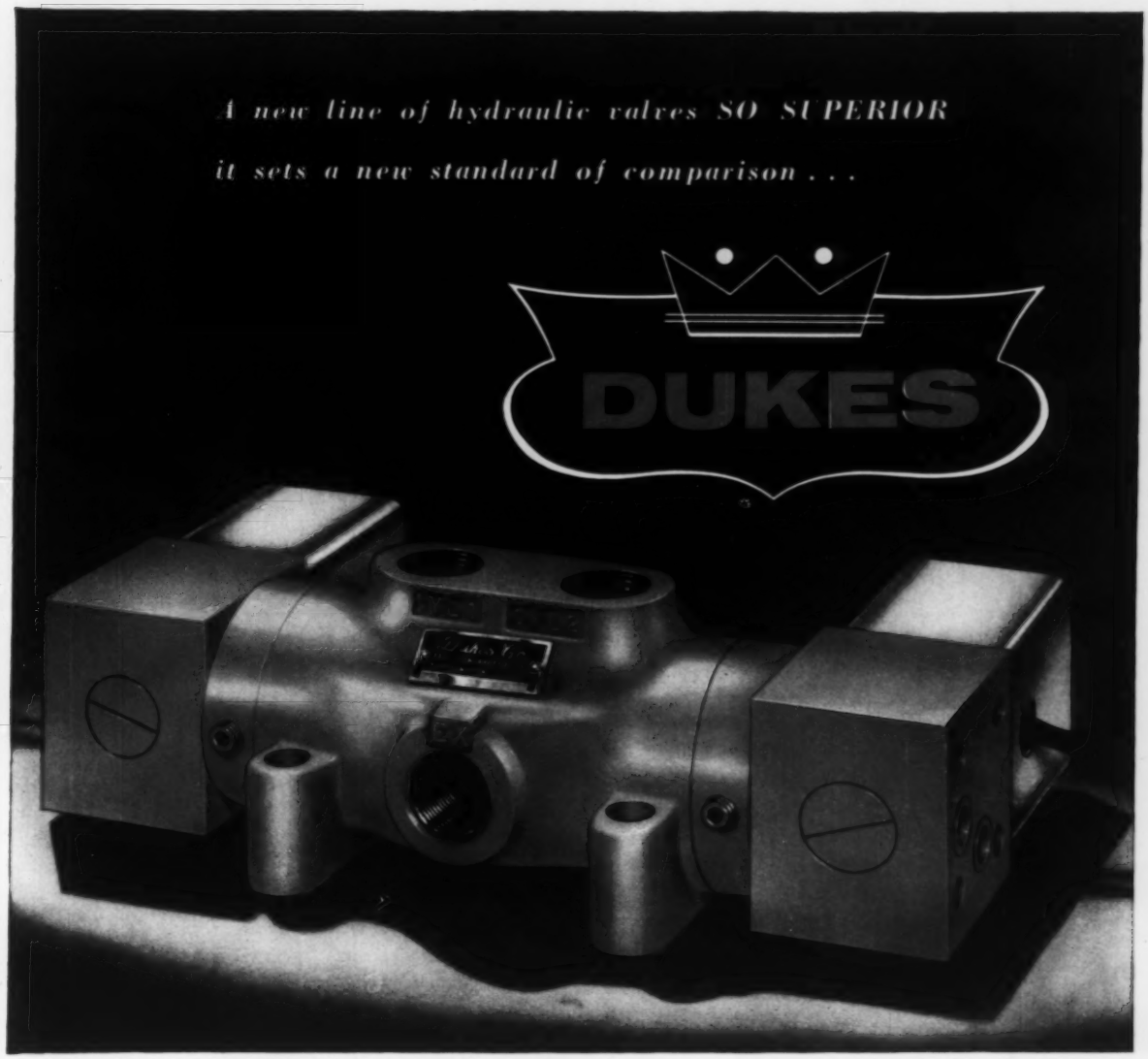
A new line of hydraulic valves SO SUPERIOR

it sets a new standard of comparison . . .



UPGRADE your requirements. This new valve will meet them

- Suitable for systems up to 3000 PSI
- Interchangeable mounting dimensions on all models
- Choice of 3 standard spools and 5 alternates, including tandem, at no increase in price
- Dry-seal pipe threads
- Gauge port for testing
- Hardened and ground spools — chrome plated and lapped to fit valve bodies

ALL TYPES AVAILABLE

- solenoid
- air piloted
- oil piloted
- stem operated
- lever operated

Send for complete new

DUKES catalog

DUKES Hydraulics

3999 North 25th Avenue • Schiller Park, Illinois • A Chicago Suburb

Circle 435 on Page 19

FOR THE MACHINERY PART

THAT TAKES THE BEATING

HAYNES Alloys *will do the job!*

An example: Knives tipped with HAYNES STELLITE alloy 6K whirl at 15,000 rpm as they strip corn cobs of their kernels. Not only do they resist corrosion, but canners report that they stay sharp six times longer than previously used cutting edges.

This is typical of the results reported by design and production engineers that specify HAYNES alloys. Parts made of these alloys are operating successfully in thousands of plants – under the roughest service conditions.

If you need a tough metal part, investigate HAYNES alloys. There are more than 15 of them from which to choose, including HAYNES STELLITE cobalt-base alloys, HAYNES iron-base alloys, HAYSTELLITE cast tungsten carbide, and HASTELLOY nickel-base alloys. They are available as castings, forgings, completely fabricated parts, or as sheet and bar stock. All parts can be furnished machined or ground to specified size and finish.

Our engineers will help you pick the right HAYNES alloy to resist practically any condition of wear, heat, or corrosion.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

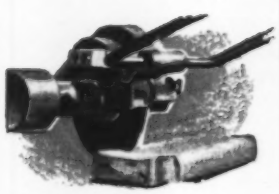
Division of Union Carbide Corporation

Kokomo, Indiana

UNION CARBIDE

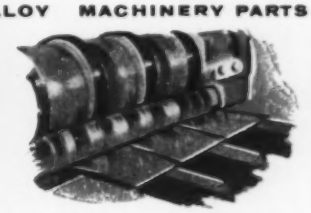
The terms "Haynes," "Haynes Stellite," "Hastelloy," "Haystellite," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

TYPICAL "HAYNES" ALLOY MACHINERY PARTS

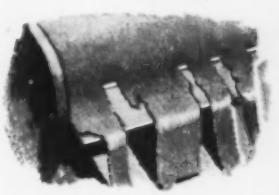


Metal-cutting saws, made of HAYNES STELLITE alloy sheet, over 20 in. in diameter slice the tops off copper ingots.

Trimming 3000 auto tires without resharpening is routine for knife blades made of HAYNES STELLITE alloy.



Slitter knives tipped with HAYNES STELLITE alloy trim miles of sheet metal in a can making operation.



Doctor blades made of HAYNES STELLITE alloy assure long service life trimming abrasive cake from filter drums.

Circle 436 on Page 19

Lord Manufacturing Company
acknowledged leader in
Vibration and Shock Control
invites you to utilize its
extensive engineering knowledge and facilities
to expedite your programs on
missiles, rockets, and high performance aircraft.

Experience with current projects such as
Atlas, Bomarc, Jupiter, Redstone,
Talos, Thor, Titan
and other missiles,
can be applied to your
vibration and shock control problems in this field.
Contact the Home Office, Erie, Pennsylvania
or your nearest Lord Field Engineer.

Circle 437 on Page 19

LORD
BONDED RUBBER

FIELD ENGINEERING OFFICES

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Houghton 1243 rubber-impregnated leather

The answer to five packing problems

- Positive seal at zero pressure
- Rubber's resilience, without rubber's friction
- Wear far surpassing either homogeneous or fabricated rubber
- Resistance to high pressures and abrasion
- Compatibility with fire-resistant hydraulic fluids and/or mineral oils

applications engineering service

Because Houghton makes both packings and fluids, they maintain a continuing packing-test program offering customer service on packings of all materials, fluids, which it also manufactures, and hydraulic and pneumatic packing applications engineering. As a result, Houghton has become "packing headquarters" for many of the leading manufacturers of hydraulic and pneumatic equipment.

An exclusive Houghton process puts pure polysulphide rubber between the leather fibers of #1243 packings. Penetration is complete.

Porosity often found in leather packings is eliminated. The packing is flexible, easy to install. There is none of the stiffness of wax-impregnation.

Wear resistance is increased by Houghton's process of molding packings with the flesh side of the leather exposed to wear, rather than the smooth, hair side. In tests, #1243 cup packings have run more than twice as long as the total service life of conventional packings, without losing the smallest fraction of their sealing efficiency.

This unique, durable material is available in pre-formed cup packings, "V" packings (which may be used in combination with Houghton rubber and fabricated rubber "V's") and "U" packings.

Write today for the latest #1243 bulletin and engineering information. E. F. Houghton & Co., 303 West Lehigh Ave., Philadelphia 33, Pa.

PACKINGS

. . . products of

E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

Circle 438 on Page 19

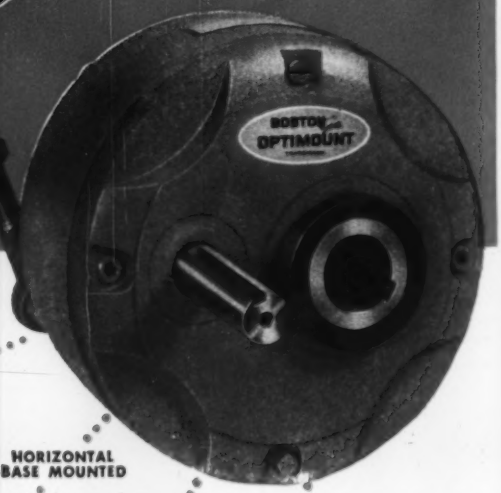
OPTIONAL MOUNTING
OPTIMUM PERFORMANCE

BOSTON Gear® OPTIMOUNT

TRADEMARK

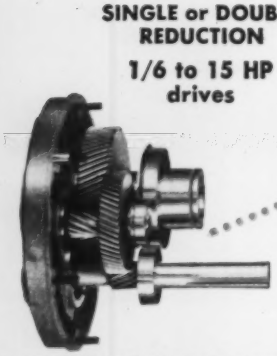
HELICAL GEARED
REDUCTORS • RATIOMOTORS
AND FLANGED REDUCTORS
SHAFT MOUNTED and BASE MOUNTED

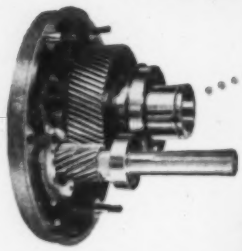
A New achievement in STANDARDIZATION
by industry's most experienced specialists in speed reducer design



From Stock

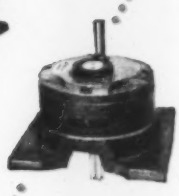
SINGLE or DOUBLE REDUCTION
1/6 to 15 HP drives





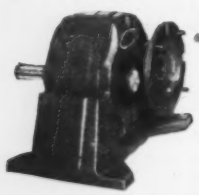
HORIZONTAL BASE MOUNTED

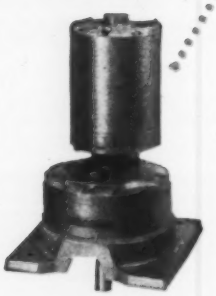
VERTICAL BASE MOUNTED



SHAFT MOUNTED

DELIVER MAXIMUM POWER with highest efficiency. Precision helical gearing made by BOSTON Gear specialists, — in units tested and proved to meet the highest quality standards.





ALL OPTIMOUNT Ratiomotors are available also without motors as FLANGED REDUCTORS. You buy and attach your own choice of motor

OPTIMOUNT offers you unlimited adaptability to modern drive demands, in helical geared speed reducers made to BOSTON Gear quality standards.

Call your Distributor for complete information. Let him demonstrate the design features that assure top-rated efficiency and lasting economy. Boston Gear Works, 64 Hayward St., Quincy 71, Mass.

66 MODELS FROM STOCK

680 OPTIONAL MOUNTING ARRANGEMENTS

For nearest Distributor LOOK UNDER "GEARS" in the 'Yellow Pages'

CALL YOUR BOSTON Gear DISTRIBUTOR

— STANDARDIZATION PAYS —®

NEW Catalog OP-1 lists complete data on OPTIMOUNT, — selection charts, engineering data. Get your copy from your local Distributor.

Circle 439 on Page 19

TEN-TO-ONE THE Copper Clad Laminate YOU WANT IS HERE!

From these ten basic PHENOLITE® Grades, you can select the base material, resin, properties and price to fit your present printed circuit need.

If your problem is finding a suitable cold-punch material, try samples of XXXP-470-1. It's designed for use in automated production equipment. If you are looking for higher heat resistance, check Grades G-10 and G-11.

Out of National's research laboratories come new advances every day. See your National Representative about new products and applications. He can keep you posted on the full line of PHENOLITE Laminated Plastic, Vulcanized Fibre and National Nylon for electronic applications across-the-board. In the meantime, write for our new "PHENOLITE Copper Clad Data" folder. Address Dept. G-6.

NATIONAL
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WILMINGTON 99, DELAWARE

In Canada:
NATIONAL FIBRE COMPANY OF CANADA, LTD., Toronto 3, Ontario

TYPICAL TEST VALUES ON COPPER CLAD PHENOLITE

GRADE	PROPERTIES OF BASE MATERIAL					COPPER CLAD PROPERTIES				RELATIVE COST
	Dielectric Constant	Dissipation Factor	Moisture Absorption	Flexural Strength	Maximum Operating Temperature	Copper Bond Strength		Hot Solder Resistance	Surface Resistance	Based on XXXP as Arbitrary Scale of 1
	10^6 Cycles	10^6 Cycles	1/16", % 24 Hrs	Psi	Degree F	Pounds to Pull 1" Strip		Secs to Blister 1" Square > Greater Than	Megohms, Etched Reima Comb Pattern, 96 Hrs./35°C/90% RH	1/16" Thk. 1 Oz. Copper 1 Side
						1 Oz	2 Oz			
P-214-B-1	5.3	.040	2.20	18,000	250	8	11	>10@ 475°F	100,000	.81
XXP-209-G-1	4.6	.037	1.90	17,000	250	8	11	>10@ 475°F	200,000	.92
XXP-239-1 PHENOCLAD	4.2	.035	0.67	15,500	250	8	11	>10@ 475°F	200,000	.92
XXXP-219-C-1	4.5	.030	0.70	15,500	250	8	11	>10@ 475°F	500,000-1,000,000	1.00
XXXP-455-1	4.0	.026	0.55	23,500	250	8	11	>10@ 475°F	1,000,000-1,500,000	1.00
XXXP-470-1	3.7	.027	0.48	14,000	250	8	11	>10@ 475°F	300,000-500,000	1.00
N-1-852-1	3.3	.030	0.20	16,000	165	8	11	>10@ 450°F	2,000,000	2.69
G-5-813-1	6.8	.018	1.00	55,000	300	8	11	—	—	2.98
G-10-865-1	5.2	.012	0.13	60,000	250	10	15	>30@ 500°F	1,500,000-2,000,000	3.49
G-11-861-1	4.9	.015	0.17	60,000	300	10	15	>30@ 500°F	2,000,000	3.55

Circle 440 on Page 19

Castings of

ARMASTEEL®

so tough they replace forgings
so machinable...they reduce
finishing costs

CLASSIFICATION	CHARACTERISTICS	HARDNESS (BHN)	MIN. TENSILE STRENGTH (PSI)	MIN. YIELD STRENGTH (PSI)	MIN. % ELONGATION IN 2 INCHES
ARMASTEEL GM 86M	Recommended for less highly stressed parts. Replaces steel parts in 1020-1035 S.A.E. range.	163-207	70,000	48,000	4.0
ARMASTEEL GM 85M	Recommended for moderate strength plus adaptability to selective hardening. Replaces parts in 1035-1050 S.A.E. range.	197-241	80,000	60,000	3.0
ARMASTEEL GM 84M	Recommended for high degree of strength. Replaces heat-treated parts in 1040-1050 S.A.E. range.	241-269	100,000	80,000	2.0
ARMASTEEL GM 88M	High resistance to wear and high yield strength, yet retains machinability. Requires no heat-treating and possesses same strength and wear characteristics as alloy steel forgings.	269-302	105,000	85,000	2.0

CENTRAL FOUNDRY DIVISION

Because ARMASTEEL castings are so machinable, so resistant to wear and shock, and so adaptable to selective hardening, they are rapidly replacing many parts formerly machined from bar stock or steel forgings.

ARMASTEEL, a pearlitic malleable iron, possesses the same strength and performance characteristics usually associated with plain carbon steel. In addition, ARMASTEEL contains excellent bearing properties, has high yield strength, good damping capacity, maximum rigidity and excellent fatigue life. Accurate control of heat-treating operations in the manufacture of ARMASTEEL produces a fine, uniform grain structure and provides excellent finishing qualities.

Four different types of ARMASTEEL can be cast to your specifications. One of the four (GM 84M, GM 85M, GM 86M or GM 88M) will have the physical properties to best meet the requirements of your application. For example, ARMASTEEL castings are being successfully used in the automotive, appliance and implement fields for such parts as gears, pistons, crankshafts, rocker arms and universal joint yokes, all of which utilize to best advantage the outstanding characteristics of ARMASTEEL.

Some of these applications are shown in the table. Look them over carefully; you may find that these characteristics and advantages of ARMASTEEL can help reduce your costs . . . increase your production . . . and improve the performance of your products.

Typical ARMASTEEL castings

Because of the greater physical properties of GM 86M ARMASTEEL, it was possible to redesign this anchor plate as shown and effect a weight reduction from 2.26# per piece to 1.44# per piece.

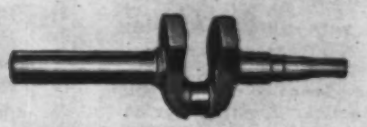
GM 86M ARMASTEEL provides the ideal casting for this automobile differential case because of its high strength, minimum deflection and good damping qualities which contribute to quietness of operation. Note the as-cast internal cavity and the well-formed webs.

GM 85M ARMASTEEL provides a crankshaft with more desirable machining characteristics than a forged crankshaft of SAE 1045 steel. Improves machining of journals and reduces checking stock. Use of GM 85M ARMASTEEL made possible the redesign of the crankshaft with a resulting 3.5# weight reduction and a lower material cost.

By converting to GM 85M ARMASTEEL, drilling and boring operations were eliminated on this crankshaft sprocket. Stock in rough part was reduced from 1.93# in forging to 1.00# in casting. Customer realized reduced piece price with GM 85M ARMASTEEL.

GM 84M ARMASTEEL was specified for this socket plate journal because its microstructure makes it more easily machined than steel with the same physical properties. It has better bearing and wear resistance qualities . . . less distortion during machining . . . and does not require heat treatment. Weight of part in rough is less than comparable steel forging.

Crankshaft for newly designed small gasoline engine. GM 84M ARMASTEEL specified because of outstanding success in similar engines. Less stock removal and better machinability are advantages over forged crankshaft.



This planet gear carrier was formerly forged from SAE 1141 steel, which required a heat treatment after rough machining and broaching operations. By converting to GM 88M ARMASTEEL, heat treatment was eliminated and the weight of the rough part was reduced.

By converting to GM 88M ARMASTEEL for this universal joint yoke, hole thru hub could be cast in . . . eliminating a drilling operation and reducing weight of part approximately 30%. GM 88M ARMASTEEL part has lower piece price than forging formerly used.

85

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 14

Circle 441 on Page 19

R B & W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By John S. Davey

Selecting the right grade of nuts

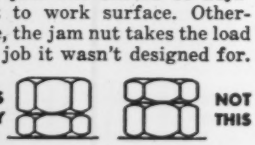
"Workhorse" among nuts is the standard "FINISHED" series. It gives good seating area; sufficient height to sustain high thread tension; enough wall thickness to control elastic nut dilation under load.

"HEAVY" nuts are wider than "Finished" nuts in *all* sizes by only ⅛" across flats. Thus, their value diminishes as size increases. Most effective in ½" to 1½" range, they satisfy applications involving excessive clearance holes, unusual loads, and certain boiler codes.

MATERIALS? The regular carbon nut steel (non heat treated). It makes nuts strong enough to pull bolts beyond yield point, lets threads distribute load to avoid stripping.

NUTS WITH "SPECIAL" FUNCTION

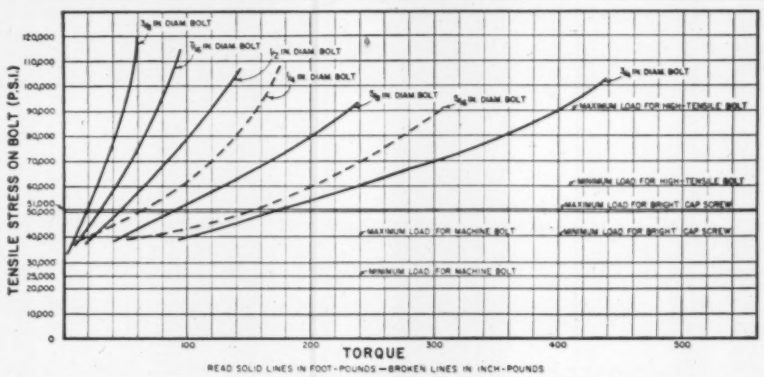
JAM NUTS are made for position locking. Use of two together forms a superior and economical locking device. When used to lock a regular nut, jam nut should be adjacent to work surface. Otherwise, the jam nut takes the load — a job it wasn't designed for.



Use a 2H NUT where high temperatures call for stability.

HIGH NUTS are used for shackle, U and tractor pad bolts. They're furnished only in fine threads, therefore, and hardened. More to be recommended are *coarse thread* finished nuts.

Tightening up fasteners tightens down on costs


TENSILE STRESS ON BOLT (P.S.I.)
TORQUE
⅜ IN. DIAM. BOLT
½ IN. DIAM. BOLT
⅝ IN. DIAM. BOLT
¾ IN. DIAM. BOLT
MAXIMUM LOAD FOR HIGH-TENSILE BOLT
MINIMUM LOAD FOR HIGH-TENSILE BOLT
MAXIMUM LOAD FOR BRIGHT CAP SCREW
MINIMUM LOAD FOR BRIGHT CAP SCREW
MAXIMUM LOAD FOR MACHINE BOLT
MINIMUM LOAD FOR MACHINE BOLT
READ SOLID LINES IN FOOT-POUNDS—BROKEN LINES IN INCH-POUNDS

These curves suggest torques for proper tightening of three grades of standard fasteners. Tightening to the upper limits delivers more of the holding power paid for, and assures stronger joints. Dropping below minimum values wastes fastener strength, invites loosening and failures. These curves are reproduced in RB&W Booklet DC-1.

It pays to go the limit in tightening bolts. Not only is it more economical, but safer too. For strength of a rigid connection depends on *residual tension* rather than on how strong the bolts are. Applying this fact can help avoid cost penalty.

EXAMPLE:

Blueprint specifies alloy bolts with strength of 145,000 psi. But assembly specification calls for tightening to what has been found an adequate pre-loading . . . only 30,000 psi. This wastes the fastener's capacity. It provides no more joint-strength than supplied by a *far more economical* RB&W bright cap screw tightened to same pre-load. It would be better to switch to the lower grade, or reduce size of the premium grade fastener.

REDUCING SIZE ALSO SAVES

A fastener's holding power is the same as its pre-load, or residual tension. So long as it permits tightening to the required pre-loading, the bolt can be small as possible.

EXAMPLE:

Design requires fasteners with safe load capacity of 20,000 lbs. Bright cap screws of ¾" size will do it; but so will ⅝" RB&W High Strength Bolts — *at less cost*. Actually, for the same holding power as in $1.00 worth of high tensile fasteners, $1.50 worth of bright cap screws are required.

PRODUCTION BENEFITS

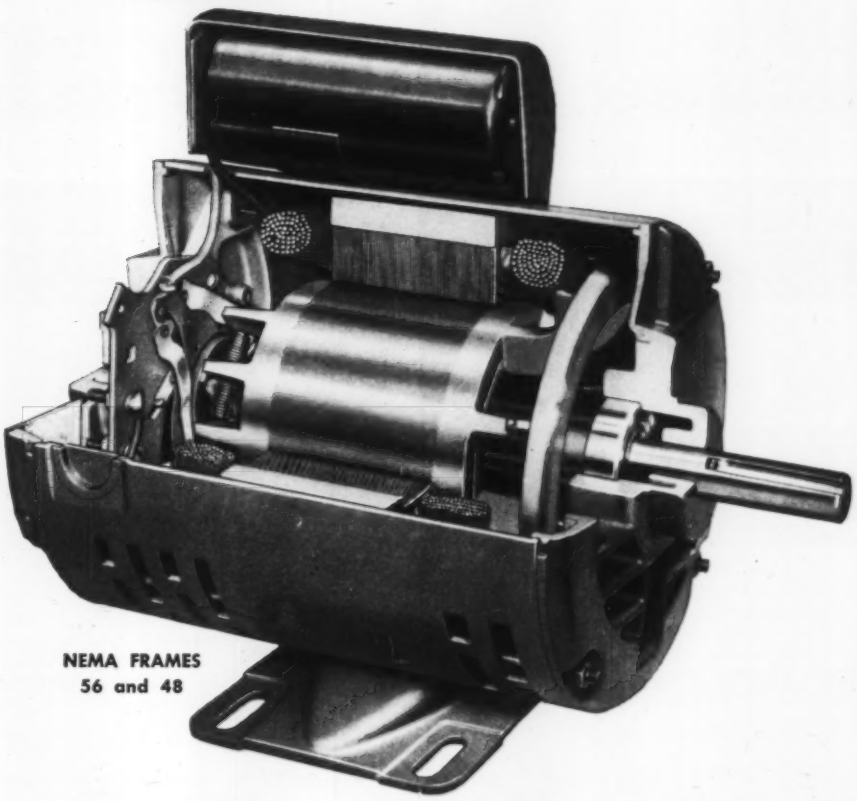
Along with direct savings, smaller bolts mean smaller holes to drill or tap. Smaller holes often allow reduction in size of fastened members.

Talk to an RB&W fastener expert at the design stage of your product. He can help you cut costs without cutting joint strength.

Meanwhile, send for helpful booklet DC-1. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

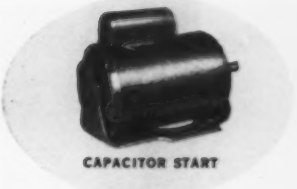
Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

NEW R & M Fractional HP Re-Rated Motors



NEMA FRAMES
56 and 48

SPLIT PHASE

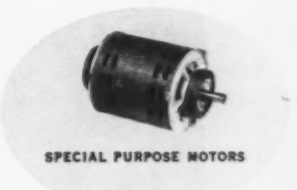


CAPACITOR START

PERMANENT
SPLIT CAPACITOR

POLYPHASE

OPEN AND TOTALLY ENCLOSED
SLEEVE OR BALL BEARINGS
RIGID, RESILIENT OR END MOUNTING
NEMA C FLANGE



SPECIAL PURPOSE MOTORS

MORE POWER...LESS WEIGHT AND SIZE!

Think of the advantages these new motors offer your products! Many new R&M Re-Rated Motors are less than half the weight of former designs. For example, the new R&M ¾ hp, 1725 RPM single phase motor weighs 26 pounds as compared to a former weight of 56 pounds. Performance, torque and overload service factors are well within national standards. Lightness and compactness have been accomplished by the selective use of lighter metals and more efficient double end ventilating.

Design versatility is an advantage too! R&M Re-Rated Motors in NEMA Frames 56 and 48 are available as complete "off the shelf" motors with a wide choice of mountings, bearings, mechanical and electrical characteristics in sizes from 1 to ⅛ hp. They're also available as motor parts without end heads. Write for Bulletin 450-MD.

Robbins & Myers build motors from 1/200 to 200 horsepower

Where production quantities justify, experienced R&M application engineers welcome the opportunity to furnish a design best suited to your particular power requirements.

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO | BRANTFORD, ONTARIO

MOTORS · FANS · HOISTS · MOYNO PUMPS · (INDUSTRIAL) PROPELLAIR FANS

Circle 443 on Page 19

NEWEST OF THE GARLOCK **2,000**

New Low Cost

True Carbon Seal Ring with precision lapped surface. Regarded by all experts as the finest material for one face of any mechanical seal. Perfectly flat sealing surface contacts stationary seat.

WE INVITE YOU to compare this new inexpensive Garlock seal with those you are now using. It is designed for use on any rotating shaft of home water pumps, oil pumps, reduction units, washing machines, etc. Get all the facts, call your local Garlock Representative or write for data.

This new low cost mechanical seal is another important addition to "the Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals for every need. The only complete line . . . that's why you get unbiased recommendations from your Garlock representative.

GARLOCK MECHANICAL SEAL

has "Gem-like" Qualities!

The finest quality materials, design, and workmanship have been incorporated in this new low cost Garlock Mechanical seal for 5/8", 3/4", and 1" diameter shafts.

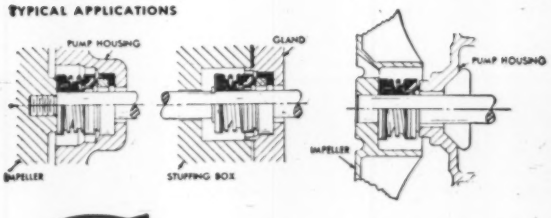
Stationary Seat of finest Ceramic is mounted in a molded cup-shaped vibration ring. Its sealing surface is precisely lapped for perfect contact with the carbon seal ring . . . perfectly matched for positive sealing.

Costly Two-piece Shell Construction. Shell rolls over a retainer ring which holds "O" Ring (static seal) in place and also provides a metal surface which gives you an exact mounting position. No danger of incorrect mounting due to improperly located static seal.

Static "O" Ring in Groove permits mounting seal from either direction without disturbing position in shell. Withstands higher pressures (100 psi.) and permits tighter fits than square shaped rings.

Roll Type Bellows provides greater travel than "V" type bellows.

TYPICAL APPLICATIONS



THE GARLOCK PACKING COMPANY, Palmyra, New York

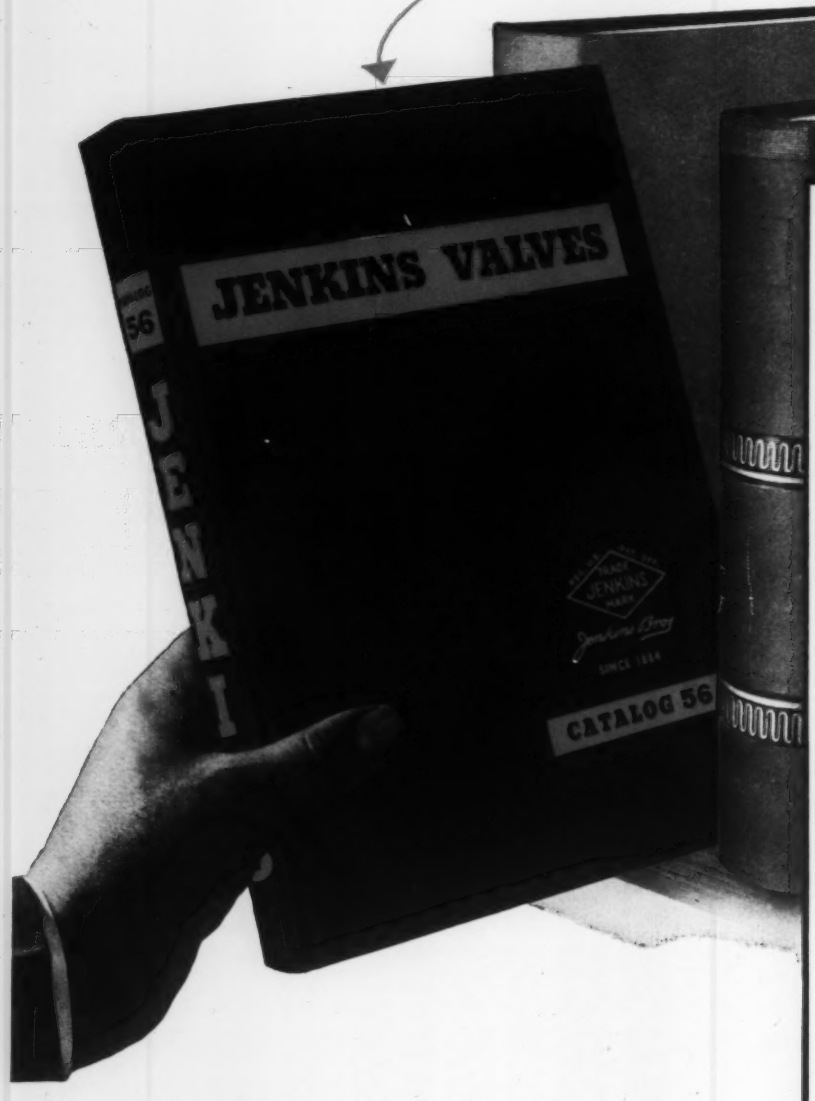
For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada. Write for Folder AD-161.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

Circle 444 on Page 19

DO YOU HAVE THIS HELPER?



HELPFUL FEATURES

FOUR TYPES OF INDEXES LEAD QUICKLY TO DATA NEEDED
Four-way indexing—General, Alphabetical, Fig. No., and Sectional—leads the reader instantly to the information desired, from any point of reference . . . pattern, metal, number, or function.

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Every Jenkins Valve in every group,—Bronze, Iron, Cast Steel, and Stainless Steel—is fully illustrated and described in detail, with an explanation of its principal advantages and uses.

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Thirteen pages of basic information,—"Fundamentals of Valve Design and Application"—serve as a guide in selecting the correct type of valve, and provide instructions for their proper installation and maintenance to assure maximum service life.

USEFUL TABLES AND REFERENCE DATA TO WIN FAVOR OF ENGINEERS
In the 23 pages of the "Engineering Data" section, Catalog No. 56 provides a compilation of useful required tables, charts, and codes —the information wanted by the men who plan piping layouts . . . *and specify valves.*

For clear, complete, easy-to-find data on valves and how to select and use them, no other single book compares with this latest Jenkins Catalog

From cover to cover this 296 page general catalog of Jenkins Valves was designed to give specifiers and buyers all the data they want . . . and FAST. It's the book to reach for FIRST when you need valves or valve information. To get your copy, write (on your letterhead) to Jenkins Bros., 100 Park Avenue, New York 17.

JENKINS
LOOK FOR THE JENKINS DIAMOND
VALVES
JENKINS SINCE 1864 Jenkins Bros.

Sold Through Leading Distributors Everywhere

Cutaway section of Douglas Aircraft acoustic window used on the DC-7 below. The noise barrier is an acrylic pane (A) mounted in a foam rubber damper (B). Damper is retained in a metal pan (C). A flexible HYPALON seal (D) is compressed between the inner pane and the double thickness outer window (E). A neoprene seal (F) is cemented to the metal retainer.

Douglas Aircraft seals new acoustic window with Du Pont neoprene and HYPALON®

Douglas Aircraft has developed an improved acoustic window, designed for pressurized aircraft cabins. It is now in use on the DC-7, and a similar design will be used on the new jet DC-8. To meet the rigid demands of flight conditions, two Du Pont elastomers – neoprene and HYPALON – were selected to seal the window.

The flexible seal between the noise barrier and double pane (see D in diagram) required a resilient material with complete resistance to ozone and high color stability. In addition, the material had to show good low temperature flexibility without the addition of a plasticizer. (Plasticizers become volatile at the low pressures found at high altitudes, and condense on the window panes.)

Douglas engineers chose HYPALON because it was the only elastomer to meet these specifications. HYPALON has complete resistance to ozone. Unlike most rubbers, it can be compounded in a wide range of stable colors without sacrificing its other properties. This versatile synthetic rubber resists hardening at extreme temperatures (250° F.-350° F.) and retains its flexibility at temperatures as low as –40° F. without the use of a plasticizer.

Neoprene was chosen for the inner seal (F in diagram) because of its high resistance to ozone cracking. It retains its resilient properties in the face of heat, flexing, weather and sunlight. Neoprene is resistant to oil, chemicals, abrasion and cutting . . . and will not support combustion.

Investigate the design possibilities of Du Pont neoprene and HYPALON. Neoprene is currently used in aircraft fuel line connectors, heating system hose and cable jacketing. HYPALON is used in molded and extruded parts, fabric coating and convertible tops. For more information on the uses and properties of these versatile Du Pont synthetic rubbers, just clip the coupon below and mail today.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

ELASTOMERS IN ACTION HYPALON® • NEOPRENE

DU PONT
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Better Things for Better Living . . . through Chemistry

Circle 446 on Page 19

☐ I am particularly interested in _____

☐ Send me a free copy of *The Du Pont Elastomers* (a review of properties of neoprene and HYPALON).

☐ Add my name to the free mailing list of the *Elastomers Notebook* (contains articles based on uses of Du Pont elastomers in industry).

E. I. du Pont de Nemours & Co. (Inc.)
Elastomer Chemicals Dept. MD-6
Wilmington 98, Delaware

Name _____
Firm _____
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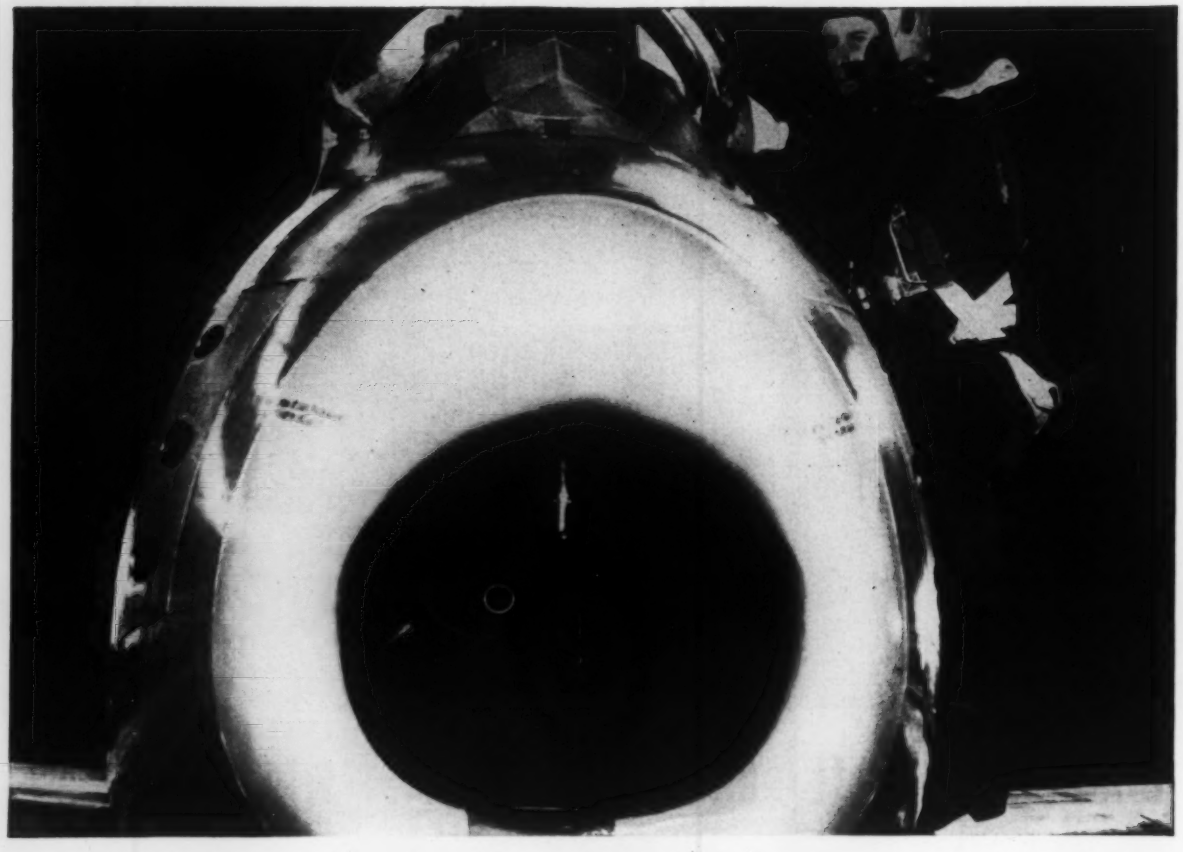
City _____ State _____



In here . . . ***a tough new alloy***

Everything this jet fighter swallows hits those buckets and blades, including nuts, bolts, pebbles, rocks, dirt, sticks and even birds.

Often, the result is a ruined engine, a crippled airplane. That's why Carpenter metallurgists devote a good share of their efforts to improving the tough alloys used for compressor and turbine parts and fasteners.

And now, they've come up with a brand new alloy steel—LAPELLOY "C", U. S. Patent No. 2,816,830.

It is more ductile and has more impact resistance than the conventional Lapelloy long used in jet engines. Its structure is more homogeneous and it has more uniform fabrication properties. Its strength is excellent at both room and elevated temperatures.

New LAPELLOY "C" is made by the exclusive Carpenter MEL-TROL process. MEL-TROL makes possible new standards of uniformity and predictable performance in specialty steels by removing the causes of inconsistent centerline quality so often found in alloys made by conventional methods. In addition to new LAPELLOY "C", Carpenter offers a wide selection of other MEL-TROL alloys for elevated temperature service.

Write for technical data on new LAPELLOY "C" and the MEL-TROL process or ask the Carpenter representative who calls on you. The Carpenter Steel Company, 120 W. Bern Street, Reading, Penna.

Carpenter STEEL

Improved alloys for elevated temperature service

All-in-one selector switch—indicating light by Westinghouse.

A start button, a stop button, an indicating light—all in one handsome, compact selector unit.

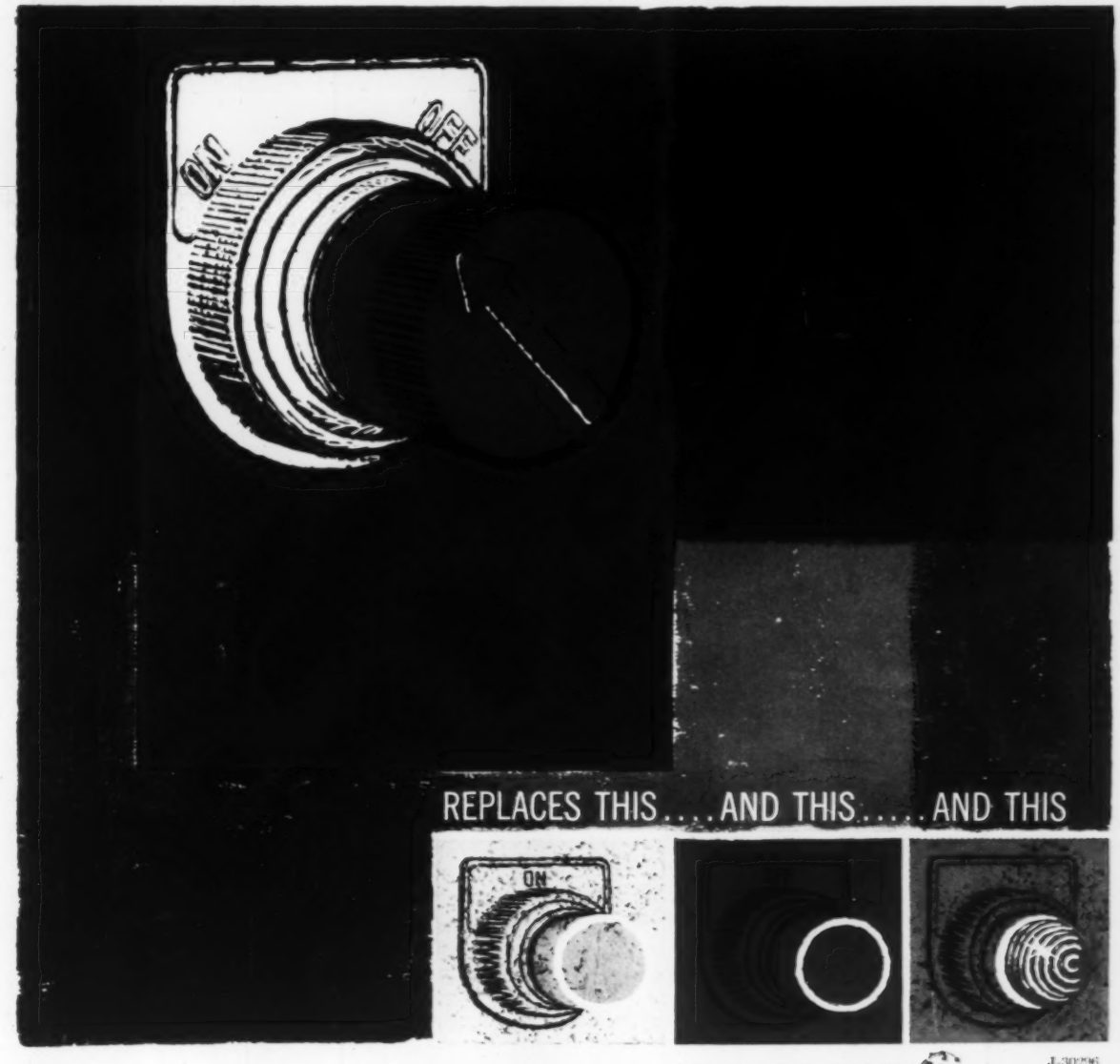
Saves up to 60% on panel space!

Saves considerable initial expense!

They're oil-tight, of course—with a panel-enhancing chrome finish—a lifetime operation snap-acting switch—and interchangeable nameplates for on-off, start-stop, forward-reverse. Or any combination you choose.

You can get full information, and a supply of Westinghouse selector-switches, by contacting your Westinghouse sales office or distributor. Or write the Westinghouse address shown below.

new select-O-lite



J-30296

YOU CAN BE SURE...IF IT'S Westinghouse

Westinghouse Electric Corporation
STANDARD CONTROL DIVISION
Beaver, Pennsylvania

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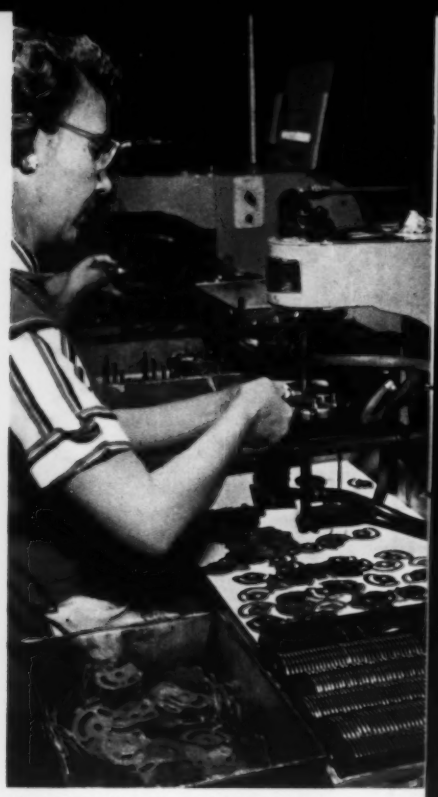
Circle 449 on Page 19→

Copper-Coated Strip, shown before heat-treat at Victor Adding Machine, prevents distortion of precision parts during case hardening of working surfaces.



Plain Steel number dials are welded to precision-made Thomas Strip.

Victor Adding Machine, Others Cut Costs, Improve Products With Thomas Strip

Manufacturers across the country are reporting new cost-cutting, quality-boosting results from their use of Thomas Strip's cold-rolled specialty steels.

At Victor Adding Machine Company, Chicago, for example, copper-coated Thomas Strip slashed one major production cost by 50% and made big savings in another operation.

Fred E. Rolli, Victor's chief engineer, says Thomas Strip is "the greatest single improvement in our production process in the past 10 years."

Here's why:

Victor's deluxe Model 75 contains 2500 individual parts, 68 of the most critical being made from Thomas Strip, both plain and copper-coated.

• **Distortion-Free.** Load-bearing parts—with tolerances under .001 inch, plus or minus, have to be case hardened along their sheared edges. Heat-treating plain steel (15 minutes at 1450 degrees) can warp the stamping. Often the expensive straightening process caused tiny surface cracks which elongated the part past the .001-inch tolerance.

To solve this problem, Victor turned to copper-coated Thomas Strip. Since the electrolytic layer of copper stops off or blocks carburizing gases, flat surfaces of the stamped part are protected. Then, plain steel edges case harden properly. The part retains flatness and proper ductility. Since there is no distortion, piece straightening of copper-coated parts is eliminated. This accounts for the 50% reduction of the total straightening operation at Victor.

• **More Savings.** A second economy begins in the punch press. Die-life is a vital factor of production costs. Like other users of copper-coated Thomas Strip, Victor finds die-life between grindings is extended as much as 33%. This is due to the lubrication effect of the copper coating.

A third benefit: uniform temper and on-spec composition of Thomas Strip mean clean, burr-free sheared edges. Burrs, like slivers, are banes of close-tolerance operation of machine parts.

• **Satisfied.** Engineer Rolli sums it up by saying:

"Elimination of straightening is one of the biggest boons to small parts manufacturers that I've seen in the business. Even if Thomas Strip had no other benefits than eliminating a production problem, using copper-coated strip would be entirely worthwhile."

Thomas Strip's advantages are the same throughout industry. Other examples of how manufacturers cut costs, improve products—get higher profits and increase sales are shown here.

Thomas Strip's newly expanded and diversified production facilities give you the full range of products on these pages, in addition to zinc and chrome coatings . . . or hot-dip coated with lead alloy or tin. Uncoated Thomas Strip products include low carbon, alloy and high carbon spring steel grades.

Steel's Strength, Brass' Beauty are combined economically to form lock-joint tubing at Van Huffel Tube Corp., Warren, Ohio. Largest producer of rolled shapes in the nation, Van Huffel uses clear-lacquered, brass-coated Thomas Strip to make tubing for variety of products, including curtain rods and lamps. Thomas' brass and lacquer coatings easily withstand forming pressures and resist roll damage to the finish. Tubes usually need no further surface finishing. Van Huffel has been a satisfied Thomas Strip user for 26 years.

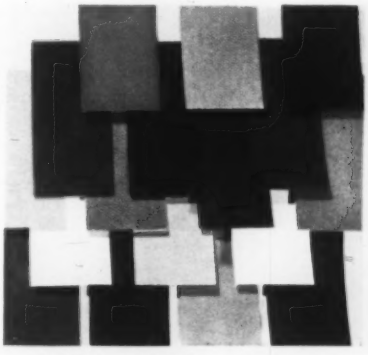
Capacity Up 25%, Sales Up 45% since Automatic Wire Goods Manufacturing Co., Bronx, New York, started using Thomas' nickel-plated strip 5 years ago. President Irving Spiegel says Thomas Strip boosted quality, kept production costs constant, improved appearance and design of his extensive Jewel and Automatic kitchen utensil lines. Thomas nickel-coated strip assures a mirror-like finish, an important feature of sales appeal in the highly competitive utensil field.

All Thomas Strip products can save you money and enhance your product in six important ways:

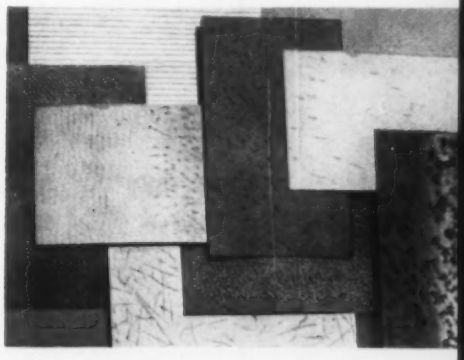
- **Fabricates Easily.** Coated steels stand fully as much fabrication as uncoated strip.
- **Longer Die Life.** Most coatings lubricate dies, reduce wear and increase tool life.
- **Maximum Pieces Per Pound.** Precision rolling to extremely close size tolerances gives more square feet of strip per ton.
- **Lower Plating Costs.** Coatings serve as final product finish or as base for further plating or painting.
- **Speeds Fabrication.** Thomas Strip coatings eliminate costly intermediate fabricating steps such as cleaning, buffing, even plating.
- **Steel's Strength and Economy** are combined with beauty and utility of more expensive metals.

All the savings and benefits Thomas Strip specialties are giving to fabricators shown here are available to you. A national sales staff—familiar with design and fabrication advantages of Thomas Strip is ready to serve you.

Write for samples, and additional cases of users' actual experiences with Thomas Strip products. Do it today!



The Rainbow's Range of colors, lacquered or painted on precision cold-rolled strip will solve your decorative and design problems. Thomas Strip's new lacquer line is the industry's finest. It's capable of wider widths in a fuller range of colors, especially pastel shades. Besides appearance, lacquer-coated steel is rugged and can be readily formed or mildly drawn without damage to the product's finish.



Unlimited Design opportunities come with pattern-rolled strip. New facilities enable Thomas to offer wider widths of any design and coating, including clear or colored lacquer. Users agree pattern-design enhances product sales appeal, permits production economies by eliminating piece buffing and costly further finishes. Pattern-designs stand up under tough forming operations and still offer attractive, flaw-free surfaces.

Thomas Strip® Division

Pittsburgh Steel Company

Grant Building · Pittsburgh 30, Pennsylvania

District Sales Offices:				
Atlanta	Cleveland	Dayton	Los Angeles	Pittsburgh
Chicago	Dallas	Detroit	New York	Tulsa
		Houston	Philadelphia	Warren, Ohio

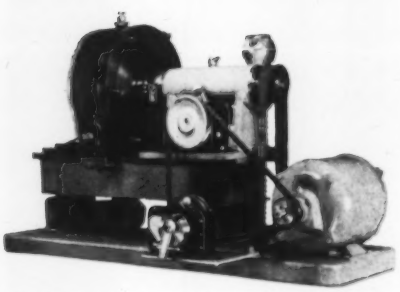
Automatic transmission seal problem—

New National Syntech® proves dependable answer in front pump seal position

Constant temperatures of 250°F, peaks of 300°, continual change in shaft speed, and total inaccessibility of the seal without costly teardown—these are a few of the sealing problems in the front pump of today's automatic transmissions for passenger cars.

To help meet this challenge, National engineers have produced a new oil seal. The new design, a steel encased, spring-loaded unit with Syntech synthetic sealing lip, is characterized by an unusually long flex section in the lip, a special, light-loading tension spring, and the time-tested, low torque Syntech lip itself.

Factory engineers report that the new National seals are proving extremely reliable in the application. Dealers also find the front pump seals are very reliable and do not require early replacement.

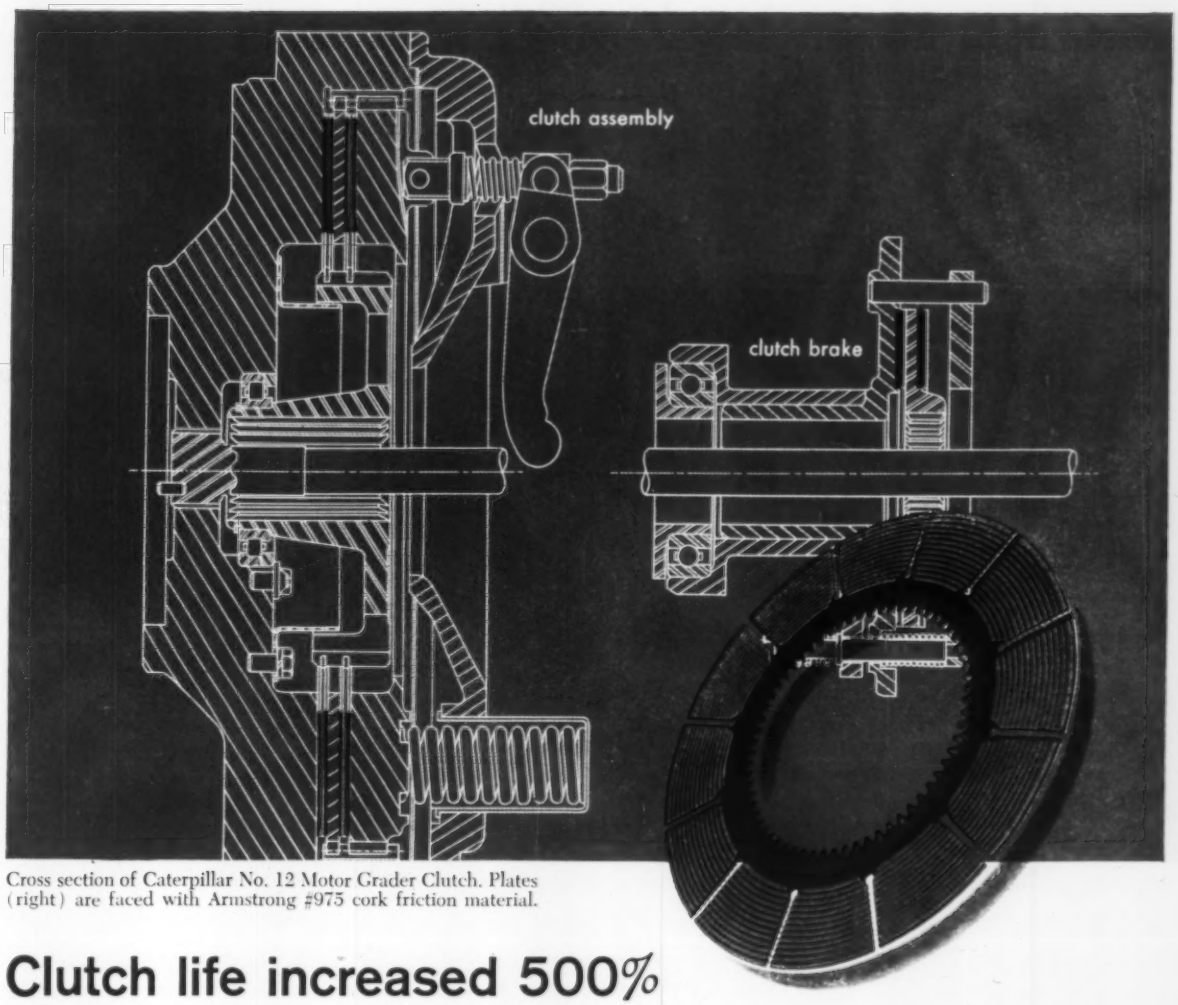


To design and thoroughly test the new seal, National engineers developed a new transmission simulator which exactly duplicates front pump operating conditions at all car speeds.

Get real help on seal engineering problems. Call the National Engineer.

NATIONAL SEAL Division, Federal-Mogul-Bower Bearings, Inc.

General Offices: Redwood City, California; Plants: Van Wert, Ohio, Downey and Redwood City, California



Cross section of Caterpillar No. 12 Motor Grader Clutch. Plates (right) are faced with Armstrong #975 cork friction material.

Clutch life increased 500% by switch to oil operation with resilient facings

Clutch designers often would like to increase clutch life and get rid of maintenance problems . . . without redesigning the unit itself. In the motor grader clutch above, Caterpillar engineers found a way to do just that.

On heavy construction and maintenance work, this clutch has to engage as often as 20 times a minute and transmit 375 lb.-ft. of torque. Field reports showed that facings were wearing rapidly, demanding frequent adjustments and eventual replacement. By converting it to an oil clutch with resilient facings, Caterpillar boosted service life 5 to 10 times and eliminated adjustments for friction material wear.

Caterpillar made this conversion without the expense of a major design change by using Armstrong #975 cork friction material. This material has the unusually high coefficient of friction common to all Armstrong facings and retains a relatively high percentage of its dry friction value when immersed in oil. In this case, Armstrong #975 provided as much torque capacity in oil as the original molded facing did dry—eliminating the need for more plates, bigger plates, or higher engagement pressure.

If you're looking for an economical way to improve the performance of your clutch, perhaps Armstrong resilient facings are the answer. The Armstrong line includes cork, cork-and-rubber, and fiber materials. These facing materials are being used in hundreds of applications, both wet and dry, under pressures up to 500 psi and at temperatures over 300° F. Your Armstrong man will be glad to provide test samples.

SEND FOR INFORMATIVE BOOKLET

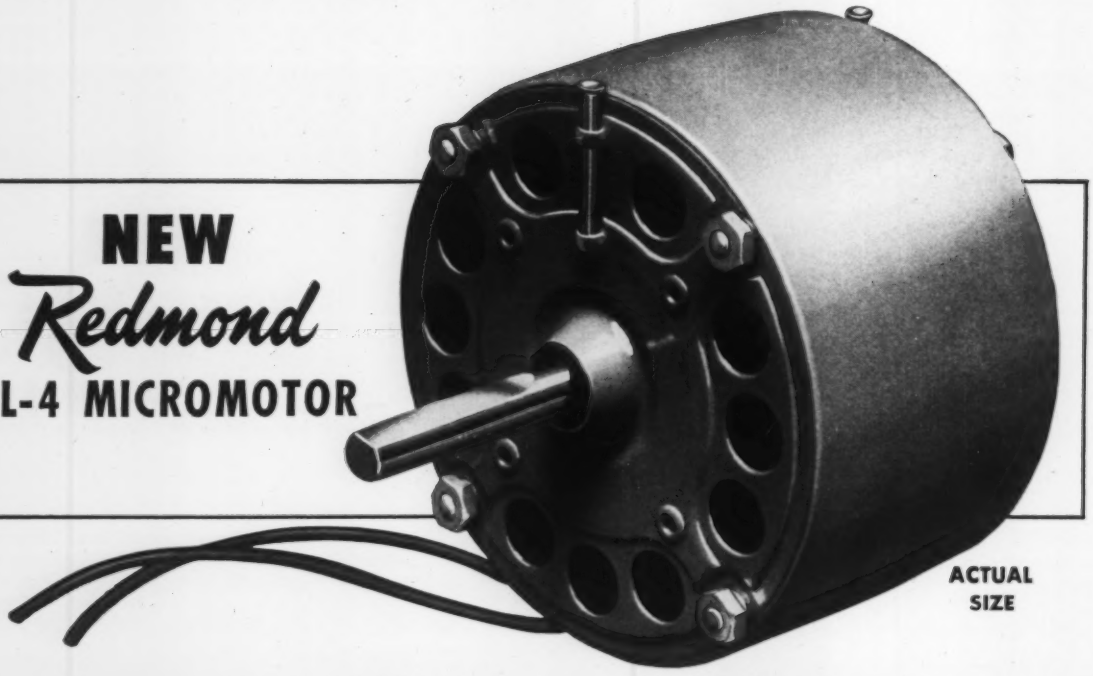
For design information and performance data on resilient clutch facings, write for your copy of "Armstrong Resilient Friction Materials." Address Armstrong Cork Company, Industrial Division, 7206 Dean Street, Lancaster, Pennsylvania.

Armstrong RESILIENT FRICTION MATERIALS

. . . used wherever performance counts

MORE HORSEPOWER in an Economical,

NEW *Redmond* AL-4 MICROMOTOR



ACTUAL SIZE

Designed for a Wide Variety of Applications . . . or can be Tailor-Made for Specific Requirements

Here is a motor designed and styled to meet the modern demands for motors that are smaller, and lighter, and yet have increased output. It is ideal for heating, ventilating, air conditioning or refrigeration equipment, for appliance applications, and for business and vending machines, pumps, tape recorders, and dozens of other applications.

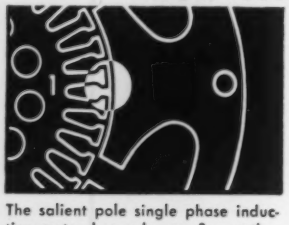
The patented Redmond Tri-Flux design, which is illustrated and described in the box below, greatly increases the efficiency and starting and running torques of the new AL-4 over conventional motors of this size.

The Redmond Uni-Cast construction allows the precision manufacturing that results in a motor that is smooth-running and quiet in operation and that can be depended on to give years of service-free performance and whisper-quiet operation.

The basic AL-4 is a 4-pole motor, 1550 r.p.m., 115 volts, 60 cycles. It is also available in odd voltages and frequencies, or in either open ventilated or totally enclosed construction. It develops 1/250th to 1/15th horsepower.

This modern motor can save money on a host of applications where economy is a factor and yet high quality is needed. If you are looking for a motor in volume quantities, let us know and we will have a sales engineer in your area contact you at once.

How Tri-Flux Design Improves Performance



The salient pole single phase induction motor has only one flux path—indicated by the white circle—between the field and the rotor. The motor is not self-starting—for commercial value a starting mechanism must be added.

The second white circle indicates the flux path added by wrapping a shading coil around the trailing pole tip. Power and uni-directional action are increased in this shaded pole induction motor, and it is now self-starting. This motor is now practical at low cost, and is used for applications requiring limited starting torque.

Note that a third flux path has been added at the leading pole tip. This was accomplished by Redmond's Tri-Flux design, whereby a "reluctance notch," which can be seen in the third white circle, is put in the leading pole tip. Efficiency and starting and running torques are greatly increased. New applications are opened to these improved, low-cost motors.

Compact, Lightweight, Quality Package

STANDARD AL-4 RATINGS

Open Ventilated FAN DUTY

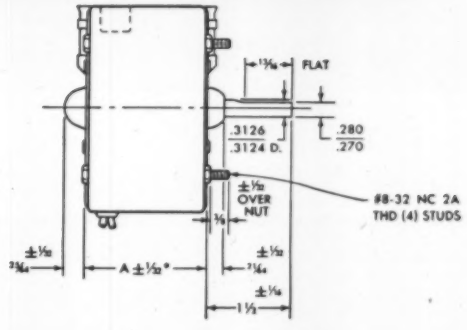
115V • 60 CYCLES • 4-POLE • 1550 RPM • ANY POSITION MOUNTING

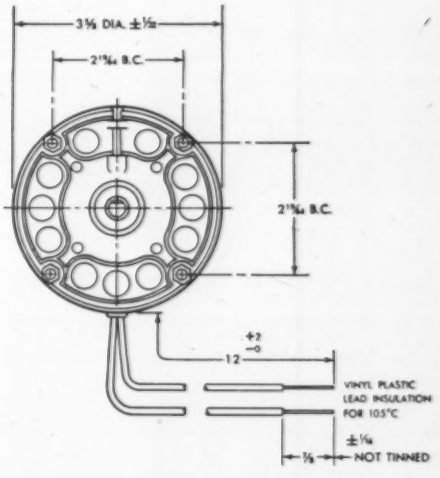
Model Number	H.P.	Nominal Amps	Nominal Watts	Oz. in. Torque Start	Oz. in. Torque Load	A±1/32*	Weight lbs-oz.	Notes
AL4700A	1/15	2.25	150	18	45	3 5/32	4—10	(1) Horsepower ratings less than 1/75 horsepower available as developed for the specific application involved.
AL4701A	1/20	1.82	120	15	33	3 5/32	4—10	
AL4400A	1/25	1.6	105	13	27	2 25/32	3— 8	(2) Totally enclosed motors are available in all sizes in reduced horsepower ratings.
AL4300A	1/30	1.35	95	11	22	2 17/32	3—00	
AL4200A	1/40	1.2	85	9	17	2 9/32	2— 8	(3) All standard model numbers are clockwise rotation face shaft end of motor. Opposite rotation supplied on request.
AL4000A	1/75	.91	60	6	9	2 1/32	2—00	

Motors are supplied standard as shown. Also available are other features of special single or double shaft extensions, 5/16" and 3/8" shaft diameters, special casebolt extensions, sleeving over leads, other lead material including multi-conductor cords, feed-thru switches, plugs, terminals, thermal overload protectors, conduit clamps, conduit boxes, triangular mounting brackets, and special or extended oilers.

Other performance ratings for various voltages, frequencies, and loads can be supplied for your product. Our sales engineers will welcome the opportunity to assist you in developing the most practical motor for your applications.

Basic AL-4 Dimension Diagram





SEND FOR COMPLETE PERFORMANCE DATA

For the complete story on the new AL-4 motor—dimensions, performance, operational data, and suggested applications—write for the "AL-4 Bulletin."

ADVERTISED IN The Saturday Evening POST

The Standard of Dependability

Redmond

COMPANY, INC.

OWOSSO, MICHIGAN

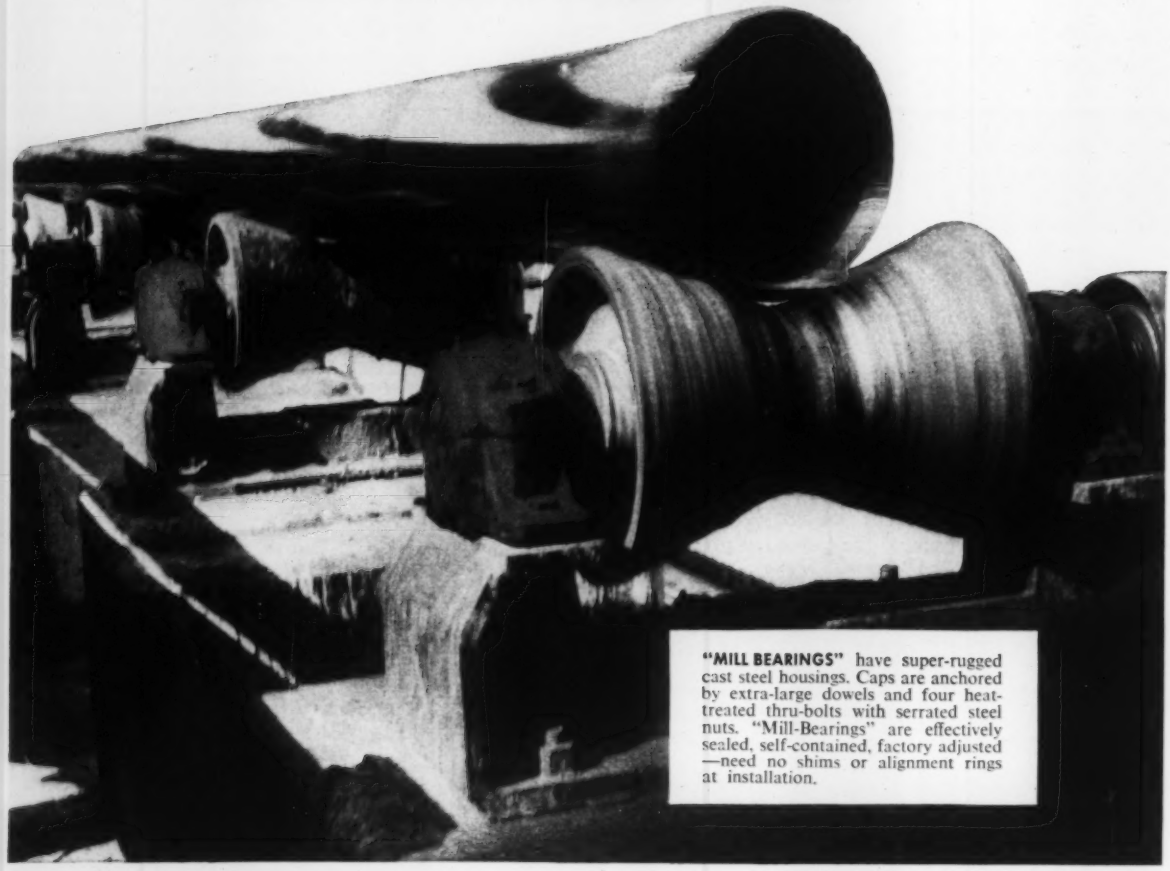
REDMOND

THE **BIG** NAME IN SMALL MOTORS

Circle 452 on Page 19

HERE'S SELF-ALIGNMENT

in a steel housing

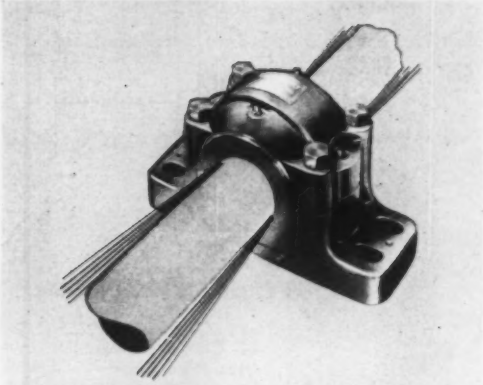


"MILL BEARINGS" have super-rugged cast steel housings. Caps are anchored by extra-large dowels and four heat-treated thru-bolts with serrated steel nuts. "Mill-Bearings" are effectively sealed, self-contained, factory adjusted —need no shims or alignment rings at installation.

LINK-BELT "Mill Bearings" compensate for shaft deflections in extra-severe applications

With cast steel housings plus *self-alignment*, Link-Belt "Mill Bearings" are a perfect match for the grind and grime of heavy loads in steel mills, mines, foundries and similar grueling service. They instantly adjust to shaft misalignment . . . accommodate minor inaccuracies of welded and concrete support structures . . . end need for extra-heavy shafting to avoid deflections which ruin ordinary bearings.

Link-Belt "Mill Bearings" are part of industry's most complete line of self-aligning ball and roller bearing blocks. You can get full information from any of 40 Link-Belt offices.



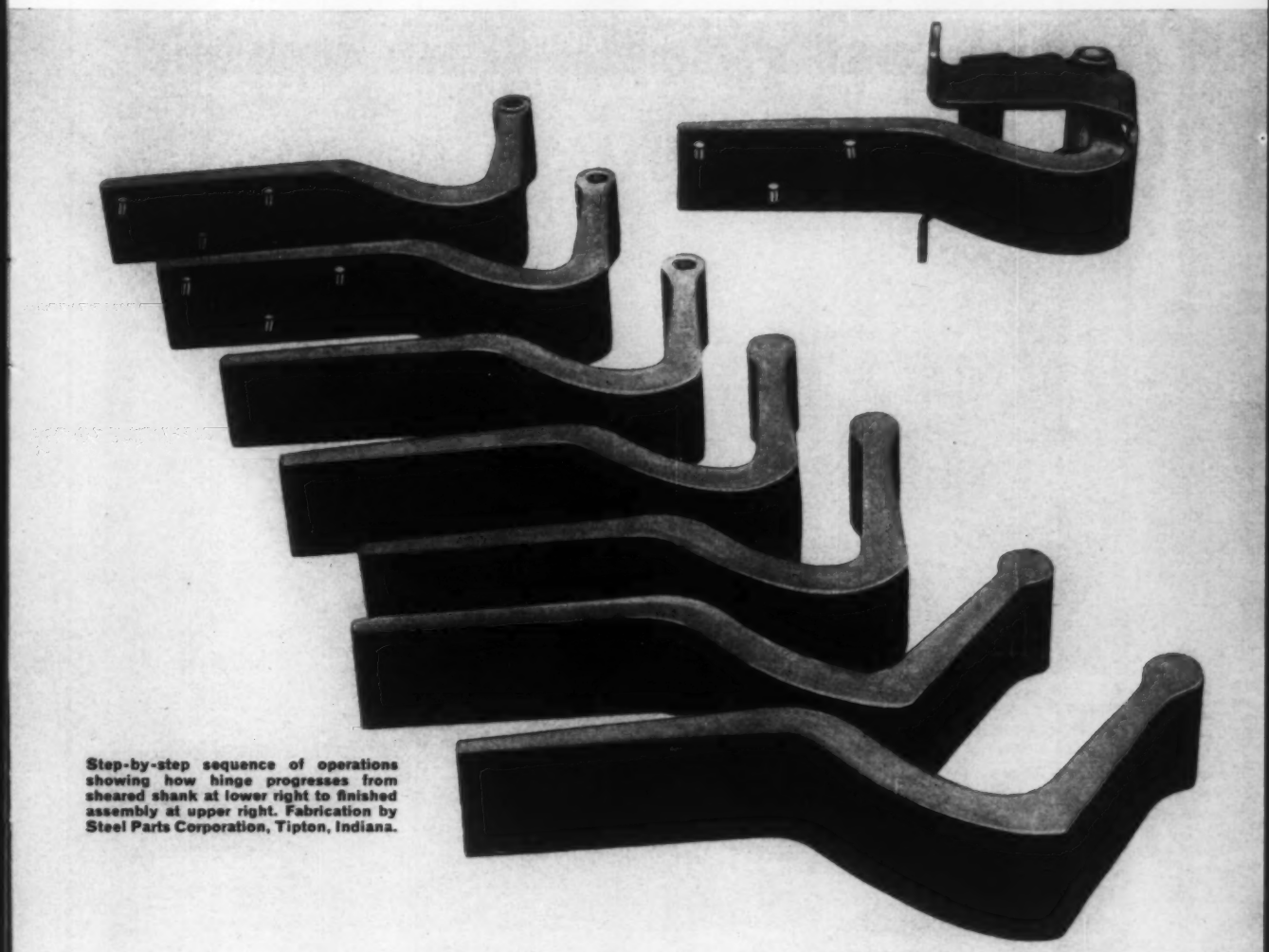
Spherical bearing is free to align in any direction, assuring full load capacity regardless of shaft deflection.

LINK-BELT

MANUFACTURERS OF SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 14,108-A

STEEL SHAPED TO CUT COSTS AND IMPROVE PRODUCTS



Step-by-step sequence of operations showing how hinge progresses from sheared shank at lower right to finished assembly at upper right. Fabrication by Steel Parts Corporation, Tipton, Indiana.

Auto door hinges made quickly . . . from steel already rolled to shape!

USS Special Section rolled to approximate dimensions of door hinge.

Hinges by the hundreds can be quickly sliced from these USS Special Section Rolled Steel Bars. Then, with a few bending, milling and drilling operations, the hinge is ready for final assembly.

This is a fast, low-cost method for producing an irregular part. There's very little machining, and scrap losses are practically eliminated. By no other method can parts like these be produced so speedily, so economically, and so strong.

Why not find out what USS Special Sections can do for you? If you are producing large quantities of parts that require extensive machining—or must be forged or cast—this method may save you money. For more information, write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

United States Steel Corporation – Pittsburgh
Columbia-Geneva Steel – San Francisco
Tennessee Coal & Iron – Fairfield, Alabama
United States Steel Export Company

USS TRADEMARK **United States Steel**

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

Avoid costly down-time caused by electrical control failure....

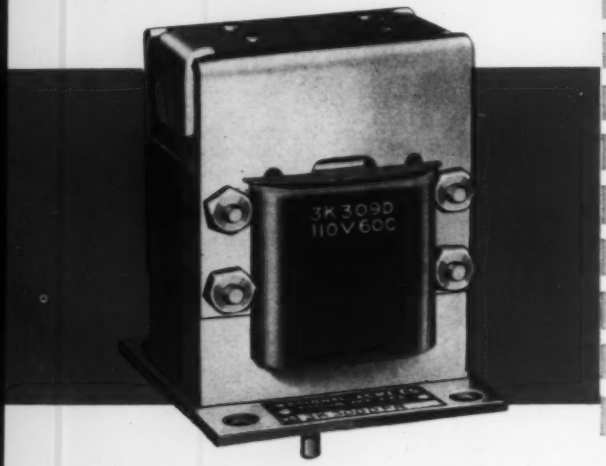
Nothing is more frustrating to the production man than downtime caused by the failure of a minor component. An $85,000 machine tool down because of a failure of a limit switch can be as expensive as if it were caused by a main bearing burnout. National Acme's electrical controls are designed by machine tool designers and built as machine tools are built. That means extra ruggedness, extra dependability but it does not mean extra cost.

GOLD-N-RING CONTROL SWITCHES

Oil-tight, water-tight, dust-tight. Built with heavy duty silver alloy contact points, over-size terminal screws, superior dielectric materials. For full information ask for a free copy of Bulletin ECS-56.

LIMIT SWITCHES

A full line of heavy duty Limit Switches designed originally for machine tool installation but now used wherever extra dependability, extra ruggedness and long life are required. For full information ask for a free copy of our Bulletin EM-51.



NAMCO SOLENOIDS

A full line of standard and custom made Solenoids for AC or DC use. Push or pull types with capacities up to 25 lbs. Bulletin EM-52A provides information on the application, design and installation of Solenoids. Write for your free copy today.

Electrical Manufacturing Division

National Acme

THE NATIONAL ACME COMPANY • 188 E. 131st St. • Cleveland 8, Ohio.

Circle 454 on Page 19

MOTIONS-IN-MINIATURE
CLUTCHES BY FORMSPRAG

ACTUAL SIZE

Now! The modern sprag principle comes to small over-running clutches

Formsprag—pioneer in the development of sprag-type clutches—now offers a truly versatile small clutch for a wide variety of aircraft applications.

In terms of your product's performance, Formsprag FS-02 and FS-04 Clutches provide unusual compactness, utmost accuracy and torque, simple and dependable operation.

Shown is a standard model. However, inner and outer races can be machined to provide through shafts, external gears, etc. Carefully controlled aviation quality and approved inspection procedures insure outstanding precision.

HERE'S REAL COMPACTNESS

	Bore Size	O.D.	Torque	Over-running Speed
Model FS-02	¼"	1¼"	50 in. lbs.	*2400
Model FS-04	⅜" and ½"	1⅝"	200 in. lbs.	*2400

*Higher speeds possible on special applications. Consult with factory.

CHECK THESE TYPICAL AIRCRAFT CLUTCH EXAMPLES

Backstop Clutch for Ammunition Feeders

Gas Turbine Starter Clutch

Oil Pump Drive Clutch

Among other uses are backstop clutches on positioning devices for electronic tubes and automatic uncoupling for energy dissipation on radar antennae drives. The FS-02 and FS-04 series can be custom manufactured in a variety of materials including stainless steel or supplied in any specified rust inhibiting process.

see our catalog in
PRODUCT DESIGN FILE
or write for copy

MORE INFORMATION?

Should you require details on these Formsprag small clutches as well as the complete line, write today for this new 26-page catalog.

Over-Running, Indexing and Backstopping Clutches for aircraft, automotive and various industrial applications

FORMSPRAG COMPANY

IN CANADA: RENOLD CHAINS CANADA LIMITED
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23603 HOOVER ROAD, WARREN (DETROIT), MICHIGAN

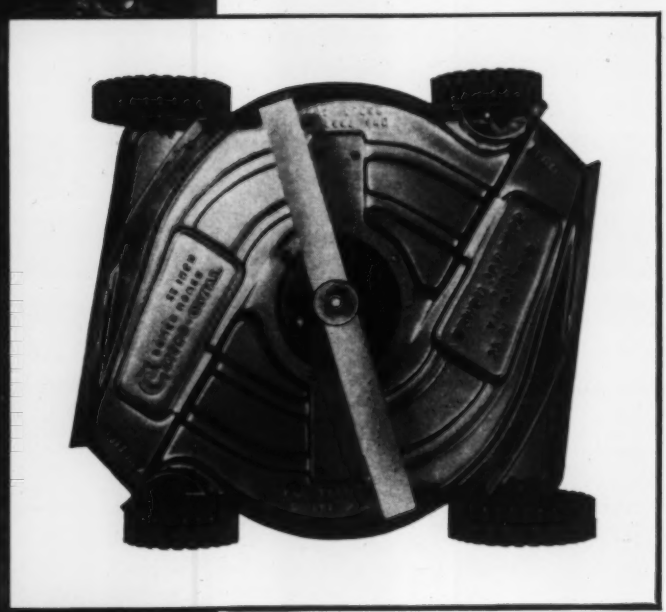
World's largest exclusive manufacturer of over-running clutches. Distributors in principal cities.

A8-2C

Circle 455 on Page 19

In Gemco Power Mowers,

REPUBLIC NYLOK FASTENERS SAFEGUARD PERFORMANCE SPECIFICATIONS



REPUBLIC NYLOK FASTENERS are used extensively on Gemco Rotary, Reel, and Riding Power Lawn Mowers. Insert shows blade assembly securely locked to engine shaft with Nylok Cap Screw. An added advantage of Republic Nylok Bolts and Cap Screws for some applications is their ability to seal against fluid escape when wrenched tight. Nylon pellet in bolt body blocks flow of fluid along helical thread path.

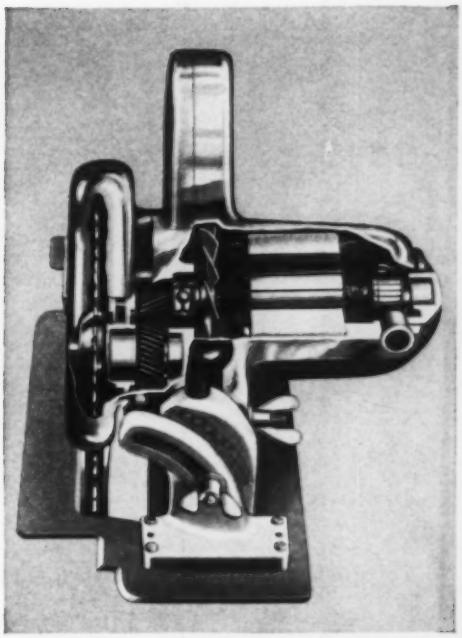
Modern Gemco Power Mowers, manufactured for General Mower Corporation, Buffalo, New York, are designed to deliver reliable, heavy-duty service with minimum of maintenance. Gemco engineers safeguard these performance specifications by using only quality materials, including Republic Nylok® Bolts and Nuts for critical assembly connections.

For example, in the Gemco Rotary Mower line, a particularly vital point is the assembly of blade to engine drive shaft. Use of a Republic Nylok Hex Head Cap Screw for this purpose assures a vibration- and shock-proof connection of maximum safety and strength. Moreover, the Nylok cap screw can be repeatedly removed and re-used to permit blade sharpening, reversal, or replacement—without loss of holding power.

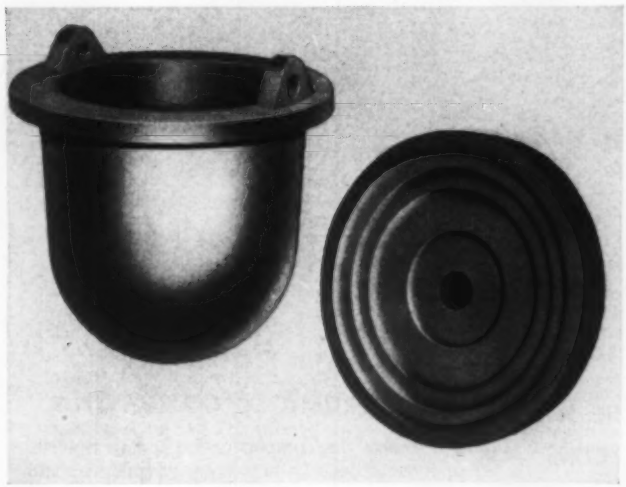
The unique characteristics of Republic Nylok Bolts and Nuts suit them perfectly to many tough fastening problems. Permanent locking is provided by a nylon pellet imbedded in the fastener body which forces a tight, metal-to-metal lock between opposite mating threads. A positive grip is maintained wherever wrenching stops. Resiliency of pellet allows both adjustment and re-use.

It will pay you to explore these and other advantages of Republic Nylok Fasteners in relation to your assembly requirements. For details, contact your nearest Republic Office, or mail coupon.

ECONOMY, CORROSION-RESISTANCE, AND PAINT-HOLDING SPECIFICATIONS make Republic Electro Paintlok® Sheets ideal for this unusual product. Produced by the Self Sett Mouse Trap Company, Cleveland, Ohio, it is a fully automatic mouse trap. Mr. E. S. Coughanor, President, found Republic Electro Paintlok best by actual test for every requirement. If you want to "build a better mouse trap" in your product field, the features of Republic Electro Paintlok may work to your advantage. For details, mail coupon.



REPUBLIC COLD FINISHED ALLOY STEELS provide required reliability in gear components of this portable electric saw produced by the Black & Decker Manufacturing Company, Towson, Maryland. The strength and toughness of these steels enables Black & Decker gears to shrug off repeated shock and heavy loading—and come back for more. Republic Cold Finished Alloy Steels may provide the perfect answer to a tough application or production problem troubling you. Send coupon for further data.



MELTING POT AND FLYWHEEL SPECIFICATIONS for these castings produced by The Union Metal Manufacturing Company, Canton, Ohio, call for a pig iron with great machinability, density, and heat resistance characteristics. Over the years, the ideal answer to these requirements has been Republic Chateaugay Pig Iron. Exclusive with Republic, Chateaugay combines high carbon with unusually low phosphorus and is copper-free. Chateaugay's uniform distribution of chemical elements produces a dense grain structure which results in economical machining, plus excellent heat- and wear-resistance. For more information, mail coupon.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
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1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send more information on:

- ☐ Nylok Nuts
- ☐ Chateaugay Pig Iron
- ☐ Cold Finished Alloy Steels
- ☐ Electro Paintlok Sheets

Name_____ Title_____

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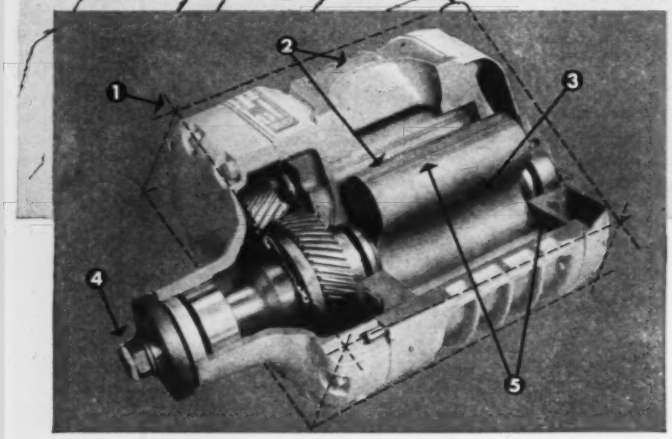
Circle 456 on Page 19

BEST for designing into new air systems . . .

BEST to specify for blower replacements . . .



① **Smallest Cube** OF ALL ROTARY POSITIVE BLOWERS
② **Heavy Duty** IRON OR ALUMINUM ROTORS AND HOUSING
③ **Wide Pressure Range** 1 TO 14 PSIG SINGLE-STAGE
④ **Wide Speed Range** 1000 TO 4000 RPM
⑤ **Exclusive Formica Wear Strips** ON ROTORS
Patented Rubber Grid Seal ON END PLATE

THERE'S A BIG DIFFERENCE WITH

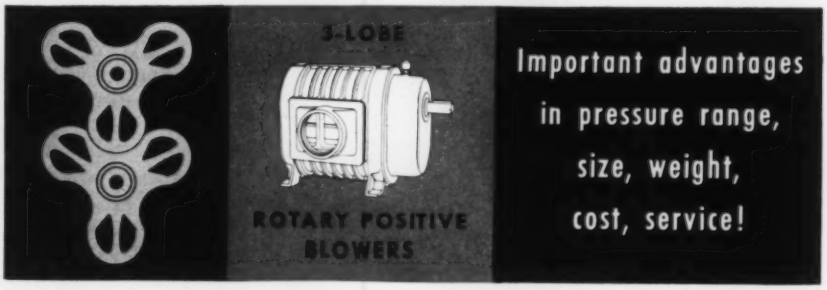
Miehle-Dexter 3-Lobe Rotary Positive Blowers

FOR PNEUMATIC CONVEYING

When specifying components for new air systems, or for replacements in existing systems, size and weight considerations are important if maximal space utilization is to be realized. When it comes to size and weight considerations for blowers, none compare with Miehle-Dexter 3-Lobe Rotary Positive Blowers. The advantages of wide pressure and speed ranges, with capacities from 50 to 4000 cfm, make M-D blowers the most efficient for moving materials by air.

The performance figures are convincing . . . write today!

Miehle Dexter



Miehle-Dexter Supercharger Division of The Christensen Machine Company, Racine, Wisconsin • Another Product of Miehle-Goss-Dexter, Incorporated

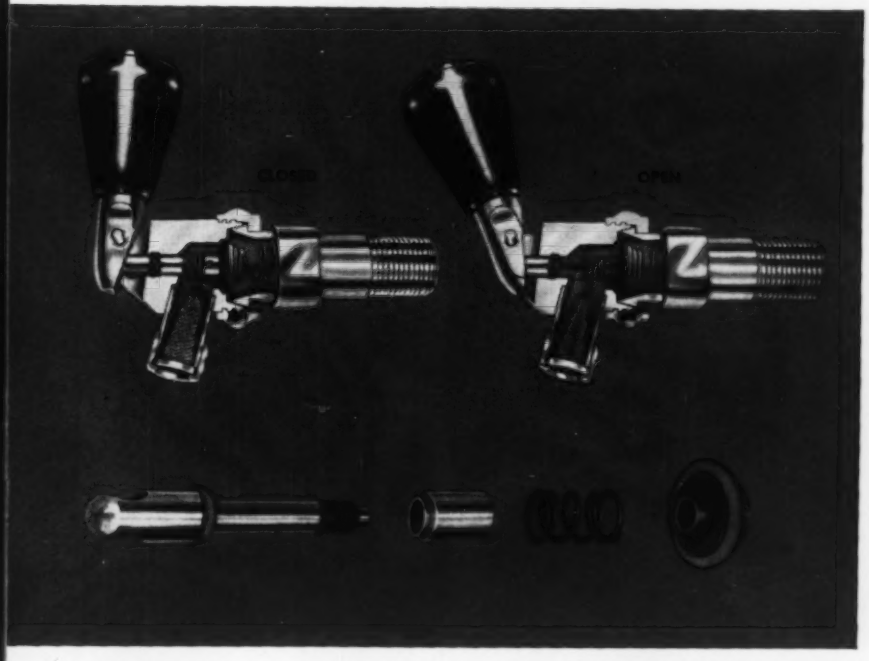
DU PONT

Better Things for Better Living . . . through Chemistry

PRODUCT ENGINEERING NEWS

LATEST PROPERTY AND APPLICATION DATA ON TEFLON® TFE-fluorocarbon resins

Redesign of valve stem to use O-rings of TEFLON® TFE-fluorocarbon resins widens range of applications of chemical faucet



NEW DESIGN, based on the properties of a TEFLON resin, makes this a truly all-around chemical faucet. Valve stem was redesigned to take new seals. The O-rings remain unaffected even when dispensing such highly corrosive liquids as rocket fuels. (Faucet by ECO Engineering Company, Newark, New Jersey; O-rings of TEFLON TFE-fluorocarbon resins by Halogen Insulator & Seal Corporation, Franklin Park, Illinois.)

The ECO chemical faucet had an inherently wide range of uses, because it was made of stainless steel. But certain limitations were imposed by failure of its seals in contact with various corrosives and solvents. A simple design change made it possible to use seals of a TEFLON TFE-fluorocarbon resin, one of the most chemically inert materials known.

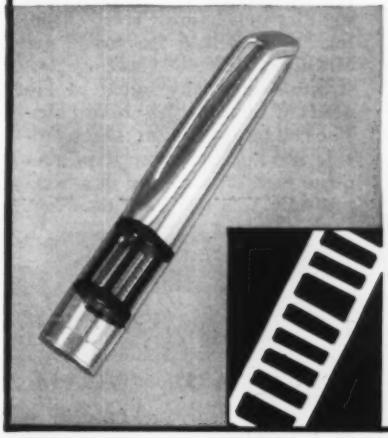
The stem was redesigned in such a way as to permit the small O-ring to be mounted without physical deformation by means of a shank sleeve. The larger O-ring is assembled into its groove by an adapter and is allowed to contract in place.

The gains were impressive. Even where highly resistive materials had undergone cracking, discoloration and failure—as in the handling of the rocket fuel hydrazine—TEFLON TFE-fluorocarbon resins showed no sign of change. They are unaffected by heat to 500°F. and do not embrittle even in liquid helium. Due to their extremely low-frictional surface, the seals slide easily . . . never stick. Tight, leak-proof closure is assured.

This is another example of the *right material* for the job . . . plus *good design.* Perhaps you can use a TEFLON resin to to get similar outstanding advantages. Learn what these advantages can be, and receive a technical report on the engineering properties of TEFLON resins by writing to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 22-6-12, Du Pont Building, Wilmington 98, Delaware.

In Canada: Du Pont Company of Canada (1956) Ltd., P. O. Box 660, Montreal, Quebec.

Liner coated with TEFLON® TFE-fluorocarbon resins prevents marring of pen



Sections of stamped copper strip coated with a TEFLON TFE-fluorocarbon resin are used to line this fountain pen cap. The smooth, low-friction coating makes it easy to slip the cap onto the pen and prevents marring of the ends. The resin protects the spring against corrosion, and its anti-stick properties prevent adhesion of ink. (Made by Waterman Pen Co., Inc., Seymour, Connecticut.)

TEFLON®

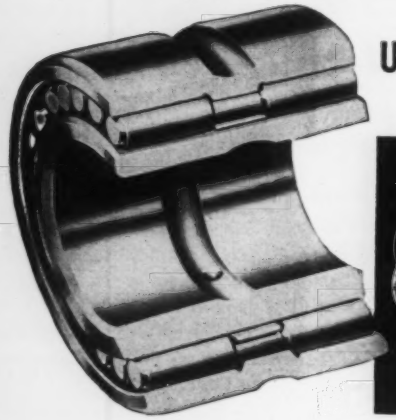
is a registered trademark...

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the TFE-fluorocarbon resins discussed herein. This registered trademark should not be used as an adjective to describe any product, nor should it be used in whole, or in part, as a trademark for a product of another concern.

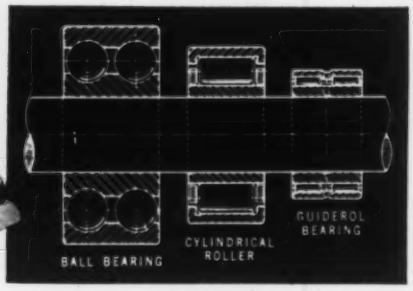
Circle 458 on Page 19

BEARING TIPS by McGill

To pack more performance in smaller space



Use space-saving McGILL GUIDEROL® needle bearings

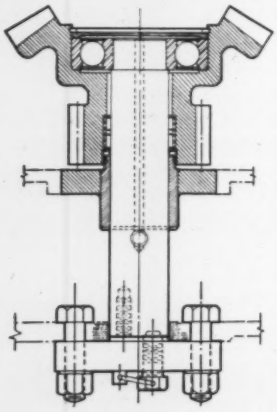


Showing graphically how a McGill GUIDEROL precision needle bearing permits more streamlined designing by supporting comparative loads in significantly smaller radial space than other types of bearings. Bulky and more costly housing space is easily avoided.

The McGill GUIDEROL Bearing combines the inherent high-load capacity of a full complement of full race width rollers with a center roller guiding principle that limits skewing and binding under misalignment. This qualifies the bearing for a whole range of applications that are too heavily loaded for a retainer-type bearing and are subject to the misalignment that precludes use of an ordinary needle bearing. For outstanding performance in small radial space, use GUIDEROL precision needle bearings. Specify the interchangeable sealed SGR series for added protection against contamination.

GUIDEROL® *bearing capacity, space economy proved in power shovel vertical reversing shaft assembly*

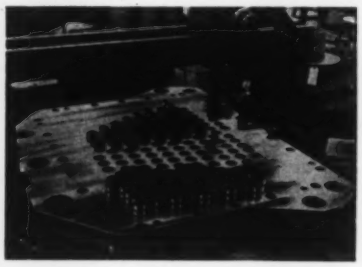
Baldwin - Lima - Hamilton Corp. uses a McGill GUIDEROL bearing, on ½ cubic yard power



shovels, to carry spur pinion loads in the vertical reversing shaft. The high capacity of the bearing in small radial space is an important factor in selection of this bearing. Only 3.75″ in diameter, it has a load capacity of 28,560 lbs. at 100 rpm. In the power shovel application, it supports 14,150 lbs. at 76.3 rpm, which gives a high margin of safety. The center guided rollers also are especially adaptable to a vertical application such as this.

Fact-packed Bearing Catalog

Write for your copy of Catalog #52-A, a 128 page Bearing Selection Guide. It contains vital product information and 30 pages of engineering data.



Multiple spindle drill heads require support of spindles on very close centers

Crowding a great number of drill spindles into a small area, Zagar, Inc., of Cleveland has found the McGill GUIDEROL bearing construction especially suited to the needs of multiple drill head units. The full bearing width rollers provide rigidity and more than adequate load capacity and in a bearing only 1.25″ in bore diameter.

Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

Circle 459 on Page 19

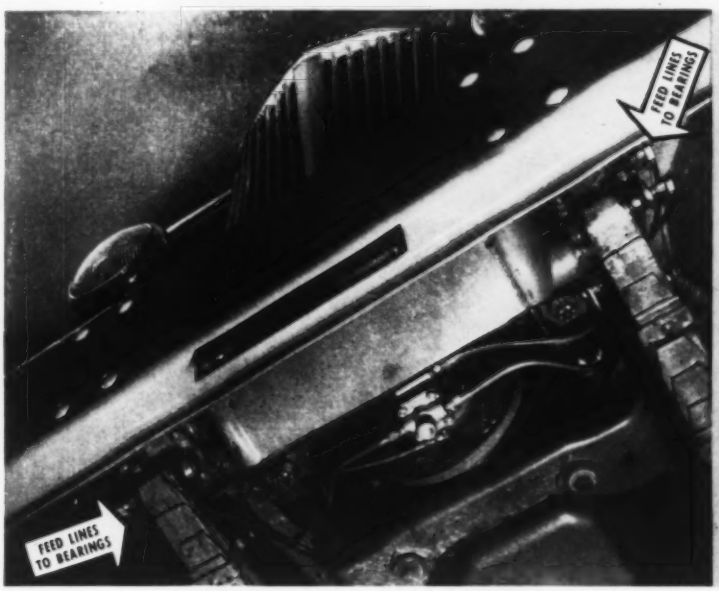
lubri-facts from Lincoln

No. 103 of a series of case histories on the vital role of lubricant application systems in engineering design.

DESIGN ENGINEERS GUARANTEE BETTER PERFORMANCE OF ORIGINAL EQUIPMENT BY INCLUDING

Lincoln Power Lubrication Systems

- Assure positive pressure lubrication to all bearings, simultaneously
- Increase machine efficiency on the road, in the plant, in the field
- Pay for themselves in lower operating costs—longer machine life



Case History:

THE WHITE MOTOR COMPANY

Perfect lubrication for White tractors is gained through Lincoln Multi-Luber* Automatic Power Lubrication. Automatically cycles with every sixth application of the brakes, forcing a measured quantity of refinery pure lubricant, under high pressure, into every bearing. Systems eliminate down-time and man-hours for lubrication . . . provide smoother vehicle operation.

The White Motor Company is typical of the many progressive manufacturers who are putting more sales power in their products . . . by increasing the performance of equipment with low-cost Lincoln Multi-Luber Power Lubrication Systems. This tested method of lubricant application permits simultaneous lubrication of all bearings in seconds . . . on transportation equipment, or on any equipment or machinery having multiple bearing points. Assures proper, frequent lubrication . . . flushes bearings as it lubricates . . . extends bearing life and eliminates costly lubrication down-time. Easy to use . . . simple to install . . . precision-built to last.

Add extra sales features to your original equipment with cost-cutting Lincoln Power Lubrication Systems. Air, vacuum, or manually operated. *Write today for complete information. Ask for Engineering Catalog No. 811.*

Most trustworthy name in modern lubrication equipment for industrial, automotive, agricultural, construction and other uses.

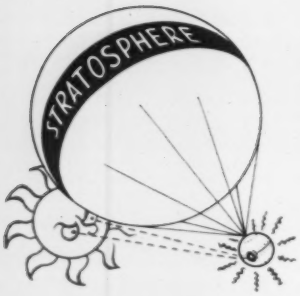
*Trade Name Registered

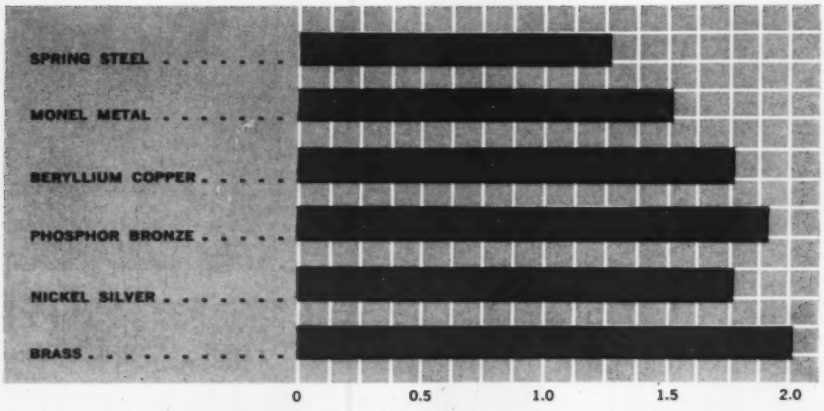
Lincoln

LINCOLN ENGINEERING COMPANY

Division of The McNeil Machine & Engineering Co.

2734 Hanrick Bridge Avenue • St. Louis 20, Missouri





How Temperature affects spring stiffness

When service or operating temperatures are above room temperature, spring selection must take into consideration several factors usually of little consequence in ordinary service.

These are loss of strength, thermal expansion, deflection, drift and hysteresis.

The first effect — loss of strength — is usually the most serious. What happens is that the safe stress carrying capacity of the spring material decreases at higher service temperatures and springs of ample strength at room temperature may be too highly stressed when heated.

These effects may be small in many cases, but under some conditions they may be important, particularly when temperatures vary over a wide range. Where an accurately determined spring strength at elevated temperature is desired, the specifications covering load test at room temperature should be corrected for the change that will occur. The approximate amount of correction for 100° F change in temperature for various materials is shown in the chart above.

With today's increasing high-temperature problems in many fields, proper spring selection is more than ever important. The subject is discussed in our latest pamphlet, "High Temperature Springs." Write for your copy.

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Chicago 14, Ill.
Milwaukee Division, Milwaukee, Wis.
Raymond Manufacturing Division, Corry, Penna.
Ohio Division, Dayton, Ohio
F. N. Manross and Sons Division, Bristol, Conn.
San Francisco Sales Office, Saratoga, Calif.
Seaboard Pacific Division, Gardena, Calif.
Cleveland Sales Office, Cleveland, Ohio
Dunbar Brothers Division, Bristol, Conn.
Wallace Barnes Steel Division, Bristol, Conn.
Canadian Subsidiary: The Wallace Barnes Co., Ltd., Hamilton, Ontario and Montreal, Quebec

5811

Streaking through the air faster than speed of sound, the B-58 Hustler depends upon nickel-containing stainless steel to withstand the tremendous heat developed by engine exhausts. B-58 is built by Convair, a division of General Dynamics Corporation.

How a nickel-containing stainless steel keeps Hustler from being "skinned alive"

At the speed the Hustler flies, heat from air friction is a problem.

Where this heat is amplified by heat from the powerful jet engines, the plane's skin could overheat dangerously . . . lose strength.

Convair engineers overcome this by cladding portions of the Hustler exposed to the exhaust blast with "honeycomb sandwich" panels made of a special nickel-containing stainless steel. Thin ribbons of stainless steel are formed into a honeycomb shape which is then sandwiched between two thin sheets of stainless steel.

They use 17-7PH stainless steel, produced by Armco Steel Corporation, because it has five times the yield strength of low carbon steel, and it retains much of its strength even at 900°F.

17-7PH stainless steel honeycombs provide the high strength, stiffness, and low weight needed by the Hustler as it outspeeds sound, 50,000 feet above the earth.

Does some metal problem face your staff?

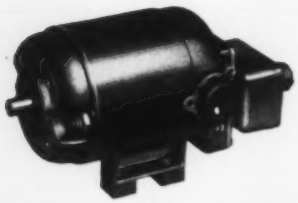
Is it a problem that involves heat, cold, corrosion, wear, stresses, fatigue? Or is there some other obstacle? There's better than a fair chance we can help your engineers get off the ground. Or at least work with them to trim the problem down to manageable size. Suggest that they send for a copy of "Stainless Steel in Product Design" and an Inco analysis sheet that will help them define the problem.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO NICKEL

NICKEL ALLOYS PERFORM BETTER LONGER

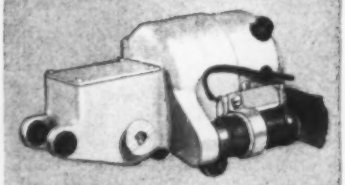
PASSES TESTS WITH FLYING COLORS



Aircraft de-icing pump motor.

Impact concrete drill motor.

Explosion-proof vacuum unit.



Gear motor for slow-speed drive.

If you are interested in any of the above motors write and we shall be glad to send full information.

. . . equal dependability for your product

One of the recent Lamb Electric developments is a motor to drive submerged pumps on military aircraft—for transfer of fuel from reserve to engine tanks.

For such an important application, motor reliability far beyond that normally called for was needed. To insure this degree of reliability in its actual operation of driving the submerged pump, test requirements for the motor were exceptionally rigorous.

As the result of advanced engineering and design, greatly increased brush life, and ability to operate at extremely high temperatures and withstand severe shock tests, the motor passed gruelling tests with flying colors.

The skill and experience exemplified here is available to your company to provide dependable power for *your* new or redesigned products.

THE LAMB ELECTRIC COMPANY • KENT, OHIO

A Division of American Machine and Metals, Inc.

In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario

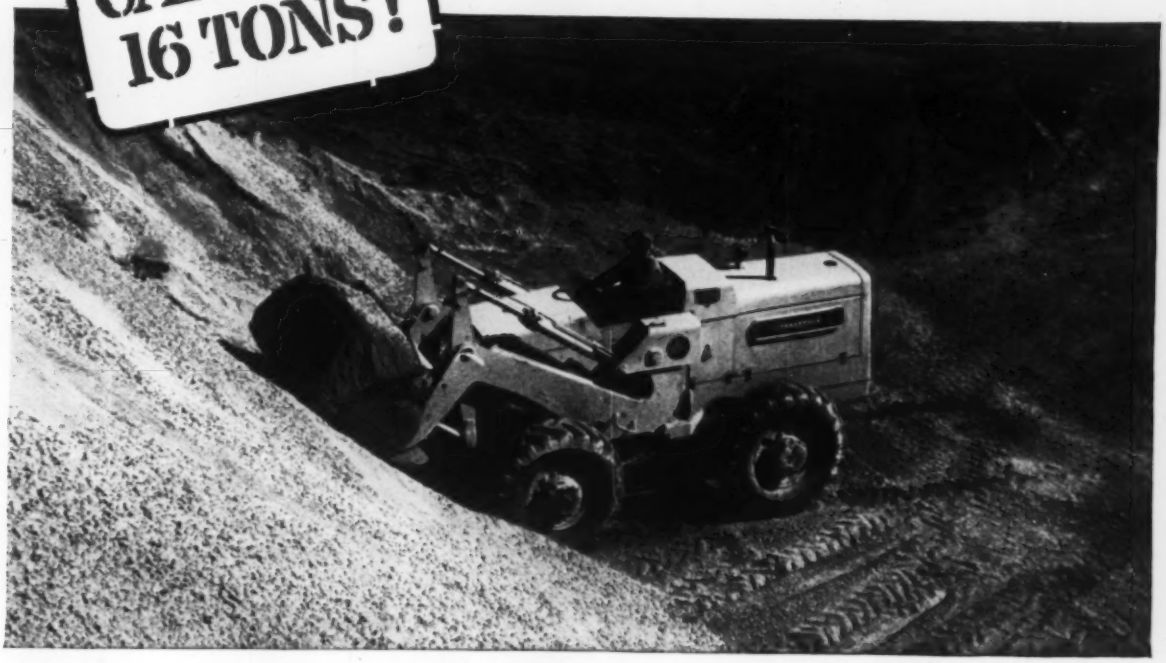
Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Circle 462 on Page 19

THIS HUSKY PAYLOADER DEPENDS ON STURDY TIMKEN-DETROIT® PLANETARY-DRIVE AXLES!

CAPACITY 16 TONS!



The continuing trend toward bigger capacities in heavy-duty materials handling equipment calls for more and more *planetary-drive axles*. That's exactly why The Frank G. Hough Co., makers of the front-end loader pictured above, went directly to the manufacturers of Timken-Detroit Axles.

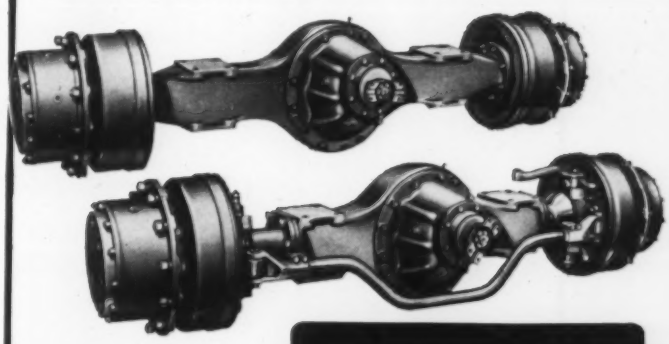
Because of their unique experience and background in planetary drives, our engineers were able to build front and rear driving axles for this loader that met the manufacturer's specifications exactly—and at real savings in both development and manufacturing costs.

Rockwell-Standard has been making planetary-drive axles longer than any other axle manufacturer. Our engineers know first-hand the problems of designing and building these sturdy and reliable drives for every type of heavy-duty, off-highway hauling and earth-moving equipment.

If you have a problem involving power transmission and propulsion, call in Rockwell-Standard axle engineers. You'll save time and money.

©1958, R-S Corp.

Timken-Detroit Rigid Planetary Axle



Timken-Detroit Steering Planetary Axle

Plants at: Detroit, Michigan
Oshkosh, Wisconsin
Kenton and Newark, Ohio
New Castle, Pennsylvania

TIMKEN Detroit AXLES
ROCKWELL-STANDARD CORPORATION
TRANSMISSION AND AXLE DIVISION
DETROIT 32, MICHIGAN
Accepted Standard

Products of ROCKWELL-STANDARD Corporation

Circle 463 on Page 19

Circle 464 on Page 19→

Get dependable operation, increased

quality for your product . . .

GENERAL ELECTRIC TRI 55 CLAD MOTORS PROVE THEY PROVIDE IT BY PASSING TORTURE TEST

HERE'S HOW: G-E Tri/Clad '55' polyphase motors are more fully enclosed than ordinary dripproof motors. This extra protection makes them suitable for many jobs which normally require splashproof motors . . . extra protection at no extra cost.

Mylar* polyester film slot and phase insulation, non-wicking leads, and water-resistant stator coating give long-life protection against *moisture*. Formex† magnet wire provides protection against heat-aging and *dirt*. Heavy-duty bearing system keeps lubricant in, abrasive dust out. And rigid cast-iron frame and endshields and melamine paint finish protect G-E motors against *external damage*.

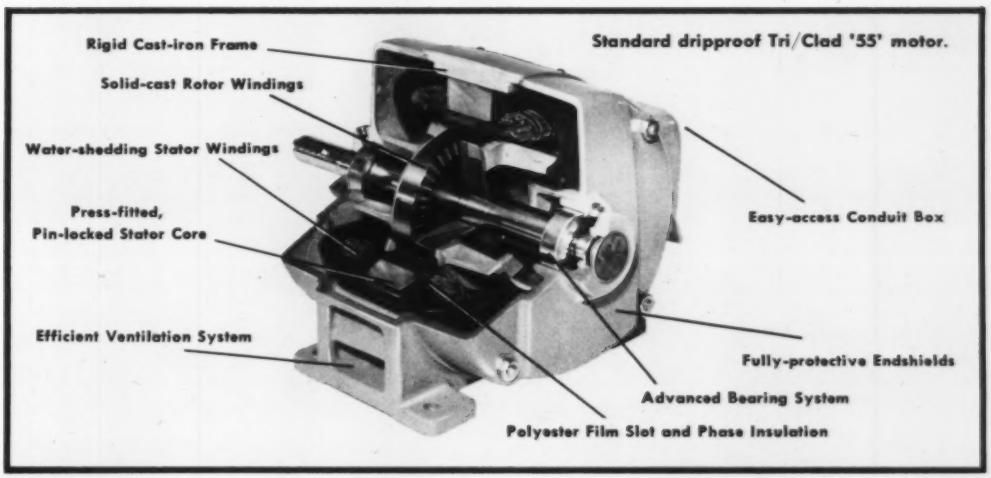
*Registered Trade-mark of DuPont Co.

These are just some of the outstanding Tri/Clad '55' motor features which mean longer life, more dependable operation—improve the quality and saleability of your product at no extra cost to you *or* your customers!

CONTACT your nearest G-E Apparatus Sales Office for *personal proof* on how G-E Tri/Clad '55' motors can give better operating protection to your products. And ask for your free copy of descriptive bulletins, GEA-5980 and GEA-6602, or write to Section 840-19, General Electric Company, Schenectady 5, New York.

†Registered Trade-mark of General Electric Co.

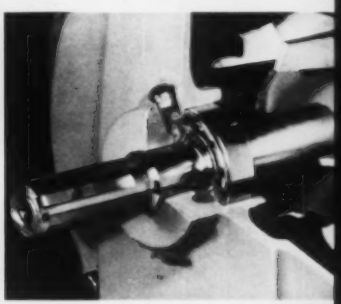
GENERAL ELECTRIC



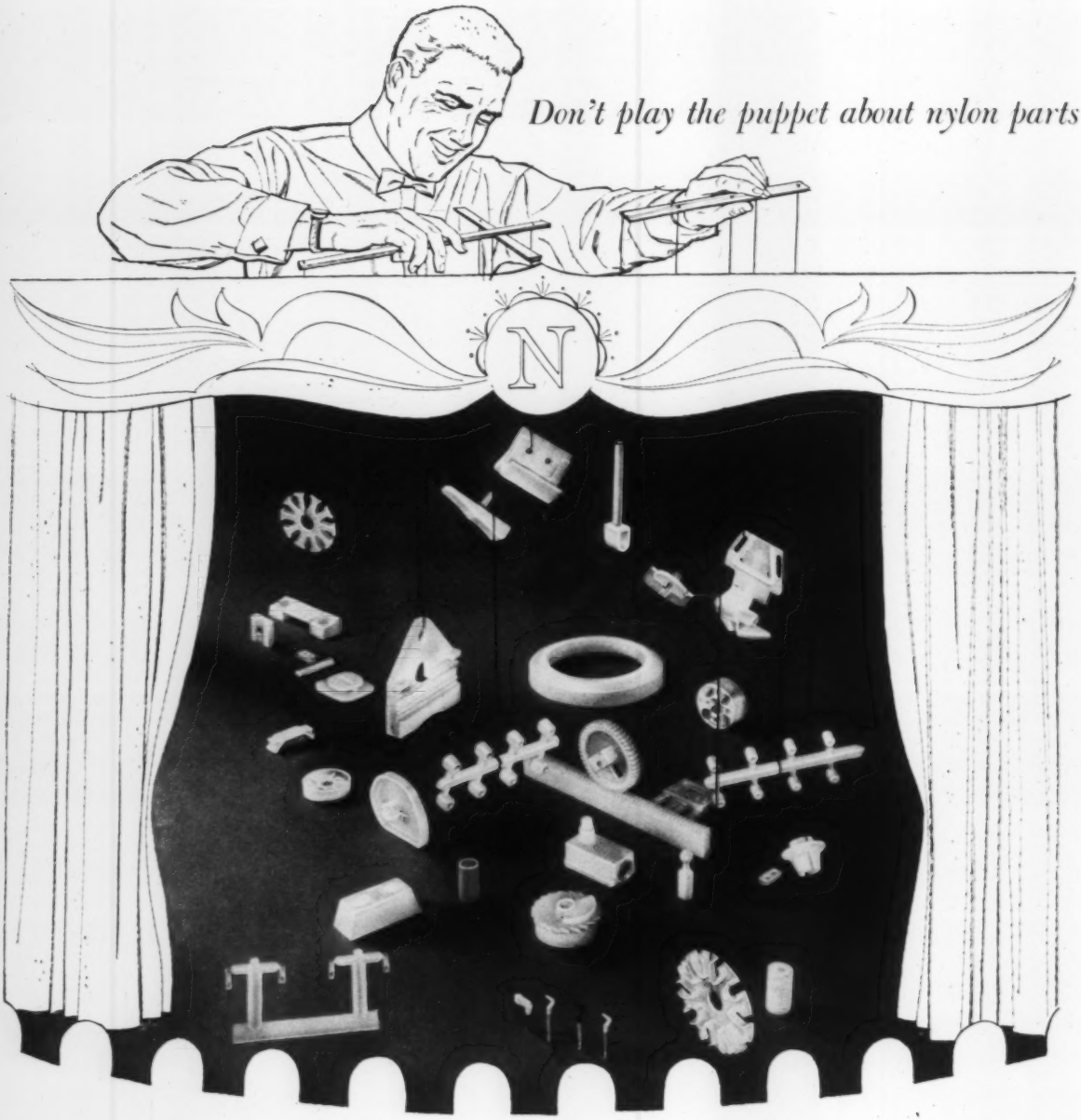
Mylar Insulation protects against moisture; assures longer motor life, minimum maintenance.

Water-resistant Coating applied to every stator assembly virtually eliminates insulation failure due to moisture.

Formex Wire insulation will not break under severe conditions—protects against heat-aging and abrasive dust.



Long-life Bearing System seals dirt out, has new longer-lasting grease, can be regreased.



NOSCO "CAN DO" KNOWS NYLON MOLDING

Don't be misled by assuming that just any injection molder can mold nylon. It's an art and requires much skill and experience. Apply this 5-point test to qualify your potential nylon molders:

1. Do you know how to design molds to compensate for temperamental nylon shrinkage?

2. Does your gating control the behavior of nylon—for uniform fill, for optimum physical properties, for minimum waste of this costly material?

3. Do you have specialized machinery for molding nylon? Non-drool nozzles?

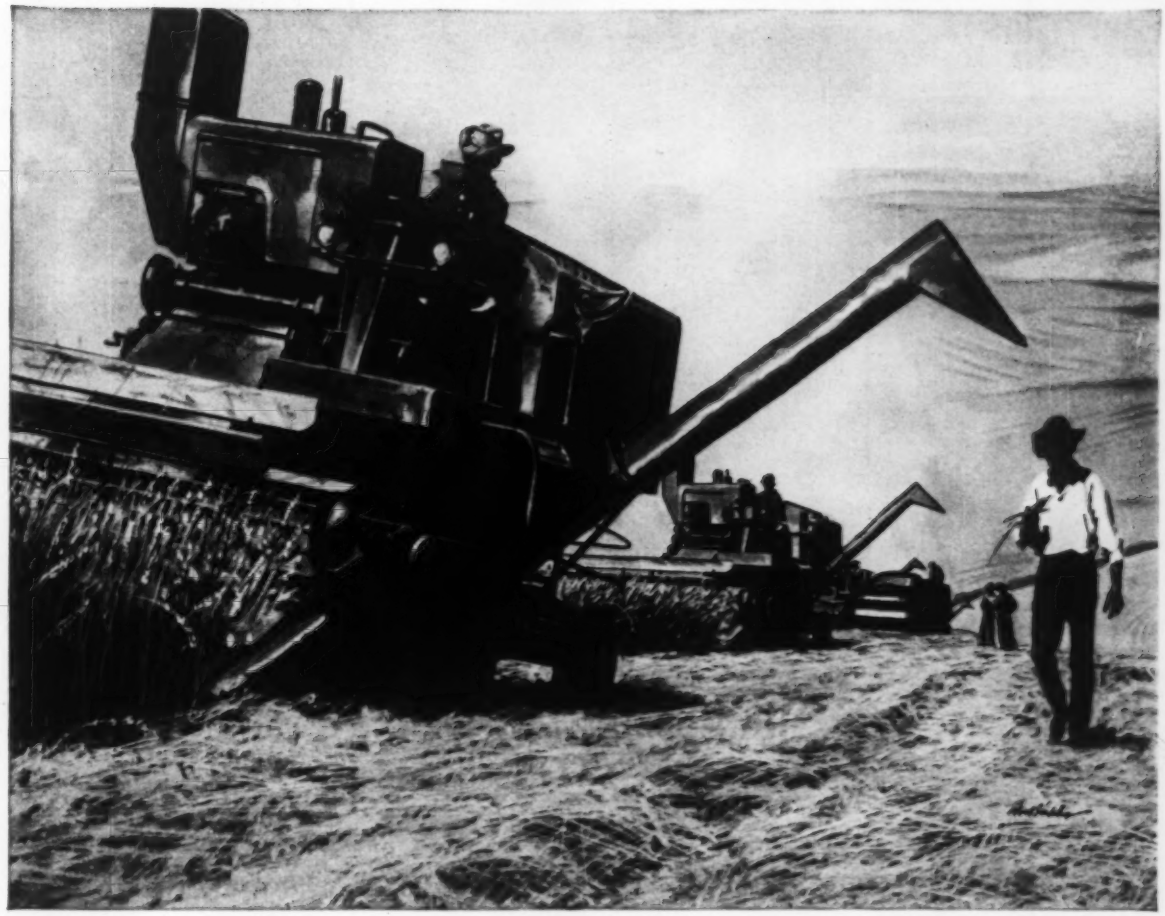
4. Do your heating cylinders provide sufficient stages for complete plasticizing without scorching?

5. Do you normalize after molding?

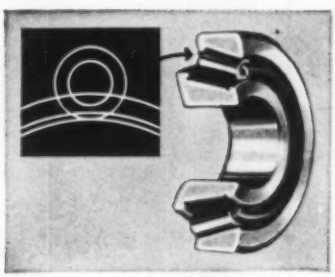
The one molder who can answer all of these questions with an emphatic "yes" is NOSCO—with more than 12 years of "can do" nylon molding experience.

It will pay you to ask for the advice of Nosco "Can Do" on your molded nylon parts. Why not write?

NOSCO plastics, inc. • erie 2, pa. *World's largest injection molding plant*



Harvest time is no time for maintenance!



HIGHER FLANGE IMPROVES ROLLER ALIGNMENT

As shown by the gray area above, the higher flange provides a large two-zone contact area for the roller heads. This greatly reduces wear—practically eliminates "end play". Larger oil groove provides positive lubrication.

No one knows the importance of proper timing better than a farmer. Equipment has to be ready *when it's needed!* One breakdown—like a bearing failure—and everybody loses. Lost crop . . . lost money . . . and, for the equipment manufacturer, a lost customer.

That's why so many farm equipment manufacturers insist on dependable Bower Roller Bearings. Basic design improvements like those shown at left have made bearing failure a rarity. In addition, Bower's use of quality material plus close attention to engineering detail has virtually eliminated all maintenance requirements—makes these rugged bearings last longer, perform better.

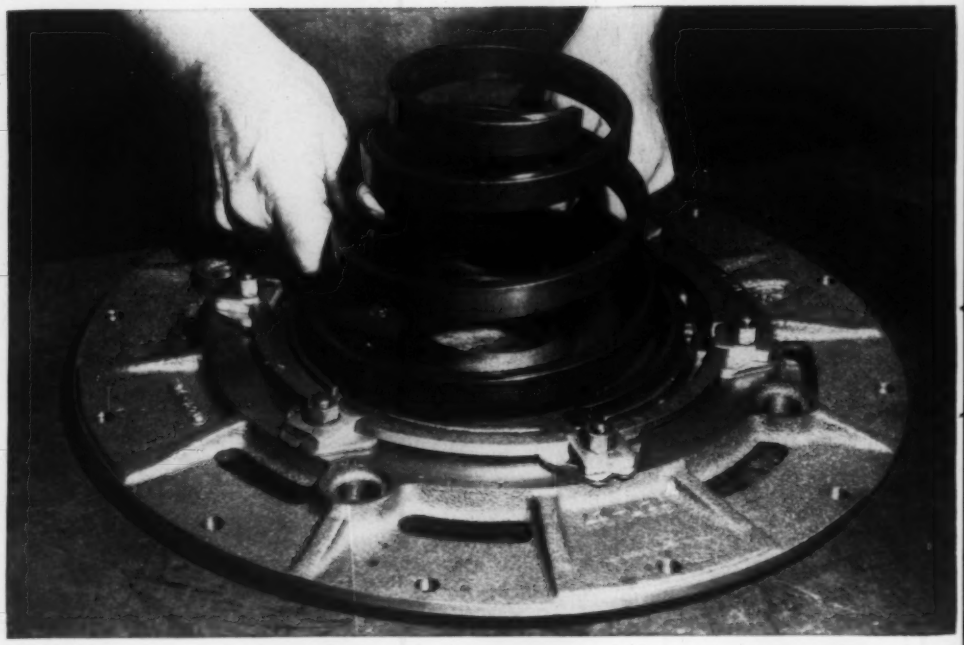
Whatever *your* product, specify dependable Bower Roller Bearings. Choose from a complete line of tapered, straight and journal roller bearings for every field of transportation and industry.

BOWER ROLLER BEARING DIVISION
FEDERAL-MOGUL-BOWER BEARINGS, INC. • DETROIT 14, MICHIGAN

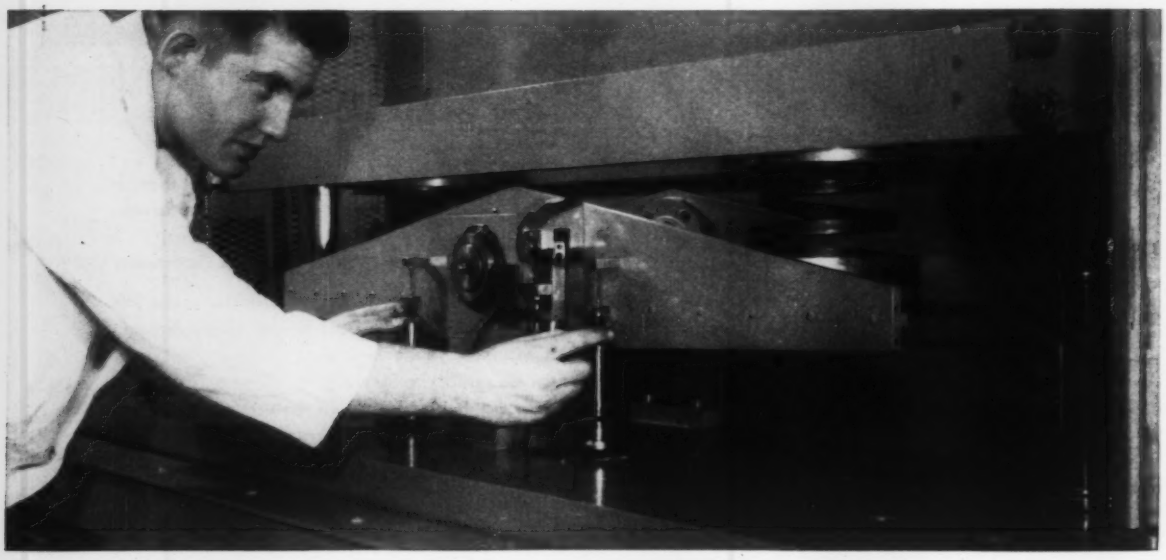
SPHER ROLL

BOWER ROLLER BEARINGS

Circle 466 on Page 19



USS American Springs give longer life,



In the AS&W Spring Laboratory a semi-resonant spring fatigue machine is testing the Lipe-Rollway clutch spring. At speeds of 700 cpm this spring is functioned beyond its normal life span and at higher than normal stresses to prove conclusively its superior design as a clutch spring.

A USS American flat wire compression spring is shown in place in the Lipe-Rollway clutch. Four round wire compression springs are also being installed in the clutch.

better performance in heavy-duty clutches

. . . thanks to AS&W Spring Engineering Research Service

The Lipe-Rollway Clutch Division, Lipe-Rollway Corporation, Syracuse, N. Y., manufactures automotive clutches for heavy-duty trucks, tractors, buses and other large mobile equipment. Because USS American Springs play a vital part in the performance of these clutches, Lipe-Rollway asked the AS&W Spring Engineering Research Service to test the springs and determine if any changes should be made in the design to improve and maintain the high performance standards.

As a result of these tests the AS&W Engineers recommended certain important changes to give the springs longer life. After this recommendation was adopted by Lipe-Rollway, Mr. Harvey Gray, Chief Inspector & Quality Control, had this to say: "Exceptional service has been realized from our American Steel & Wire Springs."

If you have a spring problem or would like advice on the use of springs in your product, get in touch with our general office in Cleveland, or any American Steel & Wire Sales Office. You can benefit from the knowledge of AS&W's Spring Engineering Research Service. The Service has been engaged in laboratory experiments of static and dynamic testing for 20 years and has accumulated invaluable data on stress and fatigue life of steel springs, while endeavoring to improve efficiency in the use of steels—from steel chemistry through product application—to more economically cope with today's rigorous demands. This accumulated knowledge of the AS&W Spring Engineering Research Service is at your disposal.

American Steel & Wire Division, General Offices: Rockefeller Bldg., Cleveland 13, Ohio.

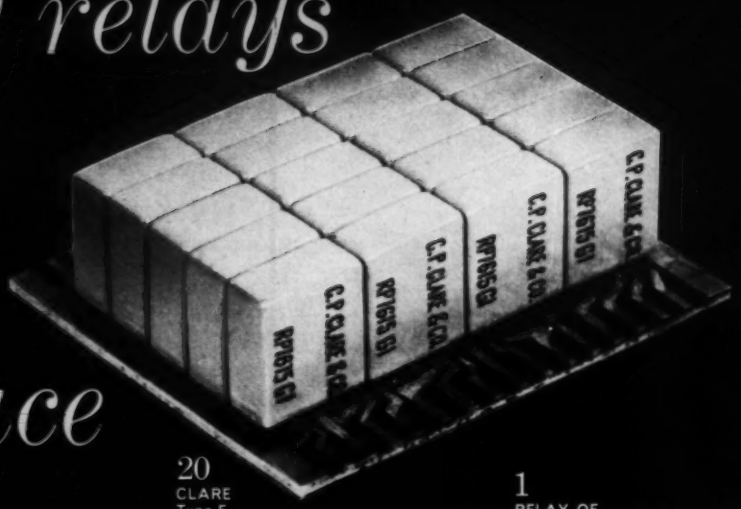
USS and American are trademarks

American Steel & Wire Division of USS **United States Steel**

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors • United States Steel Export Company, Distributors Abroad

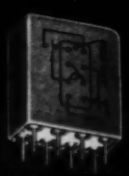
Circle 467 on Page 19

20 times as many relays in 1/3 the space



20
CLARE
Type F
RELAYS
10⅛ cu. in.

1
RELAY OF
EARLIER DESIGN
31¼ cu. in.



CLARE *Type* F RELAY

SPECIFICATIONS:

Ambient Temperature	—65° C to +125° C.
Shock	50 Gs for 11 milliseconds.
Vibration	5-75 cps at maximum excursion of ⅛-inch, 75-2000 cps at 20 Gs acceleration.
Dielectric Strength	Sea level—1000 volts rms between terminals and frame, and between adjacent circuits; 750 volts rms between contacts of a set. At 80,000 ft., 350 volts rms.
Insulation Resistance	1000 megohms minimum at 125° C.
Coils	Coils up to 10,000 ohms available for a wide range of voltages or currents.
Nominal Operating Power	250 milliwatts.
Pickup Time	3.5 milliseconds nominal.
Dropout Time	1.5 milliseconds nominal.
Contact Arrangement	2 pdt (2 form C).
Contact Rating	3 amps resistive at 28 volts d-c or 115 volts a-c; also for low-level applications.
Contact Resistance	0.050 ohm maximum.
Contact Life	500,000 operations minimum at 2 amps; 100,000 operations minimum at 3 amps.
Enclosure	Hermetically sealed, filled with dry nitrogen at 1 atmosphere pressure.
Mounting	All popular mounting arrangements available.
Terminals	Printed circuit; solder; plug-in (matching socket available). Variations of printed-circuit terminal length on 1/10-inch grid spacing available.
Weight	17 grams.
Military Specifications	MIL-R-25018; MIL-R-5757C, except as to contact overload.

Circle 468 on Page 19

These twenty Clare Type F Modular Relays, mounted on a printed-circuit board, take less than a third of the space occupied by a hermetically sealed relay of earlier design—a relay in wide use a few short years ago.

Clare Type F Modular Relays can be mounted in a closely restricted space—wherever the user desires—on a board punched at 2/10 inch intervals in a grid pattern.

This new hermetically sealed relay—no bigger than a postage stamp—is fast and more than moderately sensitive, yet stalwart enough to withstand extremes of temperature, heavy shock, and severe vibration.

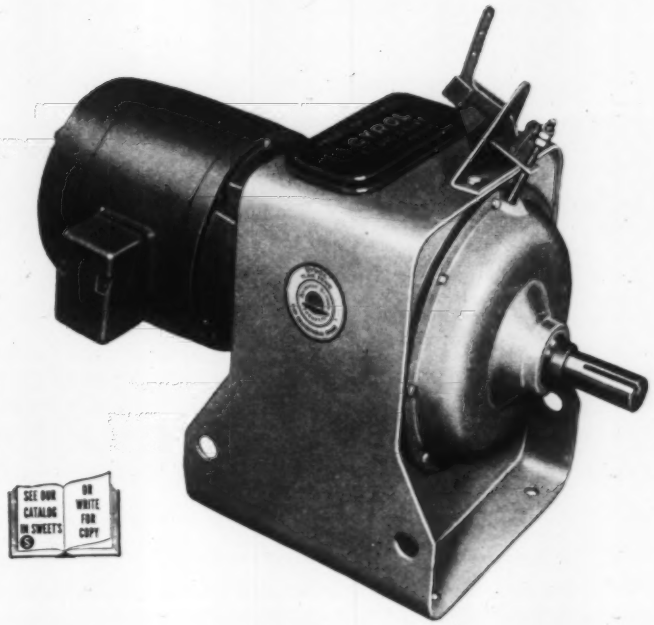
Send for Bulletin 124 today. Write: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 2700 Jane Street, Toronto 15. Cable Address: CLARELAY.

CLARE RELAYS

FIRST in the industrial field

Get full value from adjustable-speed drive:

American Blower *Gýrol*® Fluid Drive varies speed steplessly without costly maintenance

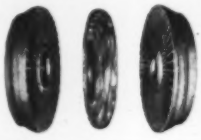


Feature for feature, American Blower Gýrol Fluid Drive is your most economical solution to many industrial-drive problems. Here's why:

- **Stepless speed control**—simple, wear-free speed controller; manual or automatic operation.
- **Shock protection**—vortex of oil isolates shock; protects costly machines.
- **Controlled acceleration**—permits no-load starting—gradual application of power to accelerate the load.
- **Full reversibility**—fast, easy; just change motor rotation even when running; provides dynamic braking.

Compact and self-contained, Type VS, Class 2 Gýrol Fluid Drives come in a complete range of sizes from 1 to 800 hp. Other designs handle up to 12,000 hp. Get full information today from one of our 73 branch offices! Or write: American-Standard*, American Blower Division, Detroit 32, Mich. In Canada: Canadian Sirocco products, Windsor, Ont.

COMPARE . . . THEN SPECIFY GÝROL® FLUID DRIVE!

Feature	Shock Protection	Maintenance Record	Accuracy	Service Limit	Horsepower Rating
GYROL FLUID DRIVE Type VS, Class 2 	Vortex of oil isolates shock.	Good—few wearing parts; extra-long service life.	Simple, wear-free speed control.	Unlimited—all Gýrol Fluid Drive ratings are for continuous service.	Units available up to 800 hp.
FRICTION-TYPE DRIVE	Mechanical connection transmits shock.	Poor—multiple wearing parts; power transmitted by friction.	Wear and tension affect control.	Limited—service factors influence selections.	Units available up to 100 hp.

* American-Standard and Standard® are trademarks of American Radiator & Standard Sanitary Corporation.

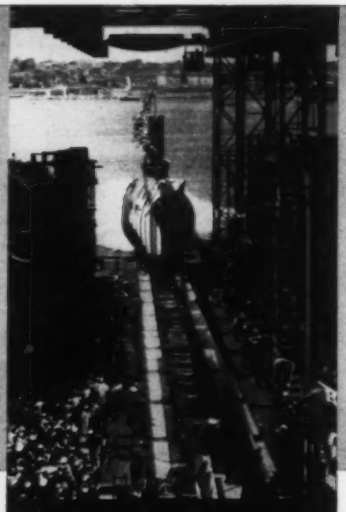
AMERICAN-Standard
AMERICAN BLOWER DIVISION

Circle 469 on Page 19

How... HEIM *Unibal*®

SPHERICAL BEARING ROD ENDS

....ARE USED IN THE... U.S.S. SKATE

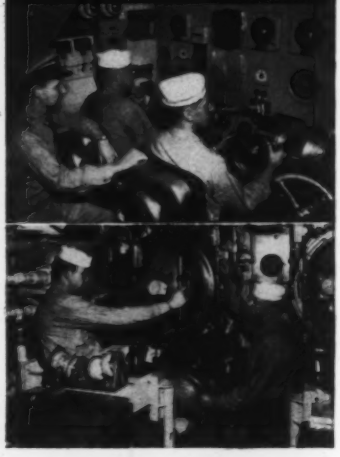


Launched in May, the atomic submarine, Skate, started its builder's trials in November, and in March, made a record crossing to Europe. Built by General Dynamics Corporation's Electric Boat Division of Groton, Conn., it is our third underwater craft to be powered through the use of nuclear fission.

FROM THE CONTROL ROOM, AIRPLANE TYPE "JOYSTICK CONTROLS" GUIDE THE ATOMIC SUBMARINE

Heim Unibal Rod Ends are used here and in the linkages and mechanisms which operate:—

- **The steering and diving gear follow-up xmitter.**
- **Emergency diving control valve.**
- **Stern diving gear.**
- **Steering emergency control valve.**
- **Stern diving gear, follow-up and transmitter drive.**



HEIM ROD END

The "Guns" of an atomic submarine are its torpedo tubes. Heim Unibal Rod Ends are used here in the torpedo handling gear.

Surface coordinates are checked through the submarine's periscope. All equipment aboard is powered by energy generated from Skate's water-cooled reactor system.

Keeping pace with technological advances, Heim Unibal bearings meet those exacting specifications so vital to the operation of Uncle Sam's fleet of atomic underwater craft. It is reasonable to assume that you do not have the plans for a nuclear-powered submarine on your drawing board at the moment, but, . . . If your product employs a push-pull motion, if power is transmitted at changing angles through linkages of one kind or another, or if the correction of misalignment is a requirement, we know that . . .

HEIM Unibal® Spherical Bearings

. . . can do all this better and for less money. Unibal is the original plain, spherical bearing developed, engineered, and manufactured by Heim for over fifteen years.

Write for catalog showing sizes, load ratings, and complete list of stock bearings. Ask for engineering help on your more intricate problems.

THE HEIM COMPANY FAIRFIELD, CONNECTICUT

Save 27% or more in cost...

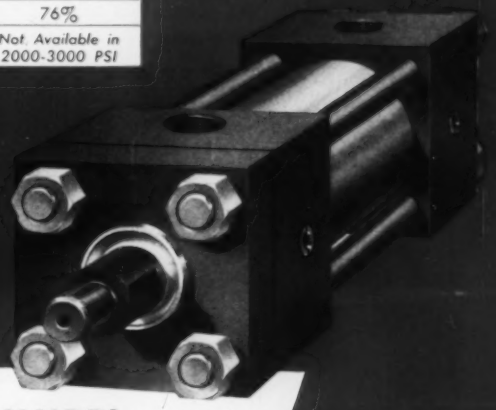
NEW

"JOB RATED"

HYDRAULIC CYLINDER LINE

JOB RATED, MODEL " J "			
BORE	SEVERE OPERATING CONDITIONS	MODERATE OPERATING CONDITIONS	YOU SAVE THIS % IN PRICE OVER STANDARD 2000-3000 PSI CYLINDERS
1½"	1500 PSI	2500 PSI	27%
2	1500	2500	27%
2½	1000	1500	28%
3¼	1500	2500	32%
4	1000	1500	35%
5	800	1200	37%
6	800	1200	43%
8	500	800	50%
10	500	800	71%
12	500	800	76%
14	500	800	*Not Available in 2000-3000 PSI*

with IDENTICAL seals, design, and safety factors as the famous Miller "Power-Packed" Model "H" Line for 3000-5000 psi service.



SEAL FAILURE MEANS CYLINDER FAILURE!

1. *No seal made of synthetic rubber is compatible with even 50% of available, commercial, petroleum base hydraulic fluids.*

MILLER Uses All Teflon* Seals to Eliminate External Oil Leakage because Teflon is impervious to all known hydraulic fluids, even fire-resistant types.

TEFLON SHEF SEAL At Tubing Ends

No blind assembly. Is
Shear-proof
Heat-proof
Extrusion-proof
Fluid-proof

TEFLON Seals On Piston Rod And Bushing

Teflon rod flange seal requires no adjustment. Teflon bushing seal is shearproof. Teflon wiper keeps dirt out.

TEFLON Seals On Ball Check And Adjusting Screw

Non-protruding, self-locking, cushion adjusting screw interchangeable with ball check for easy access.

MILLER Uses Resin-Impregnated Leather Piston Cup Seals because they are compatible with petroleum base fluids and some fire-resistant types. Teflon cups available at small extra cost.

2. *Nicked or scored piston rods cause seal failure*

MILLER Uses Case-Hardened Chrome-Plated Piston Rods because they prevent nicks, scoring and rust.

write for our bulletin giving complete details plus valuable data on column strength, cylinder forces, pipe sizes, safety factors, accelerations, air-oil devices, and other useful information.

NOW! . . . You can save MORE with quality Miller "Job-Rated" Cylinders than with cut-price, lesser quality hydraulic cylinders. And the "Job-Rated" Cylinders are also available under the same immediate shipment program as the Power-Packed Line (2 hours if necessary—3 days normal).

*For Pure Instrument for tetrafluoroethylene resin which withstands temperatures from —100° F. to +500° F. and all hydraulic fluids.

OTHER MILLER QUALITY FEATURES

- Rust-Resistant Surfaces
- Interchangeable, Space-Saving Square, 4-Tie-Rod Design
- Precision Honed Barrels

Circle 471 on Page 19

MILLER FLUID POWER
DIVISION OF FLICK-REEDY CORPORATION

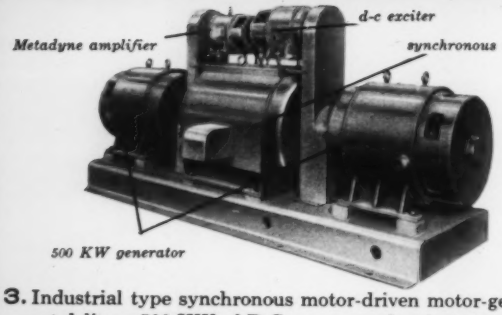
2006 N. Hawthorne Ave. Melrose Park, Ill.

AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS • BOOSTERS

1. Six 100 HP D.C. reversible motors work in unison to drive the antenna through a wide speed range. A blower with its own A.C. motor and filter cools the motor. The D.C. feedback tachometer generator closely co-ordinates the effort of all the motors.

Drives designed and built by Louis Allis

2. Control panel receives, co-ordinates and limits power to give precise selected motor speeds from full forward to full reverse with a twist of a knob — without shock to the antenna or pause in operation. The operator selects the direction of operation and motor speed — the control system does the rest.



3. Industrial type synchronous motor-driven motor-generator set delivers 500 KW of D.C. power to the six antenna drive motors. The D.C. exciter and metadyne amplifier provide a temperature-compensated, automatic controllable source of power to the motor and generator fields.

Each of six drive motors is geared to the antenna bearing. All six are used for normal operation; however, one could operate the antenna in an emergency. Several motors can be cut out without impairing antenna rotation.

New-design news from Louis Allis

Here's precise speed control... Regulation — 0.25%... Response — 0.2 seconds!

System provides accurate, split-second control for rotating radar antenna—another example of complete power-package engineering by Louis Allis.

Today's high-speed heaven-scanning calls for giant radar tracking units with rapid, exact, co-ordinated control. To meet this requirement, Louis Allis engineers recently developed a complex power package which combines an MG set, metadyne amplifier, d-c drive motors, feed-back equipment, and complete controls into an efficient system permitting antenna rotation at exact selected speeds.

Antenna drives may not be *your* problem — but whatever your industry requirement is — steel, paper, machine tool, etc. — you can rely on Louis Allis application and engineering know-how to design and manufacture the drive and control system you need.

Louis Allis expert application specialists are men who know the motor and drive requirements and many of the operating problems of almost every industry. Make use of their experience and take advantage of the unmatched line of Louis Allis standard and special motors and drives to solve your next speed-control requirement.

Get full information from your local Louis Allis District office, or write The Louis Allis Co., 459 East Stewart Street, Milwaukee 1, Wisconsin.

For specific information on Louis Allis adjustable speed drives and high frequency equipment, write for: Bulletin 2000, Select-A-Spede® Drives; Bulletin 611-E, Ajusto-Spede® Drives; Bulletin 1500, Electronic Select-A-Spede drives; and Bulletin 2250, High Frequency Equipment.

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS

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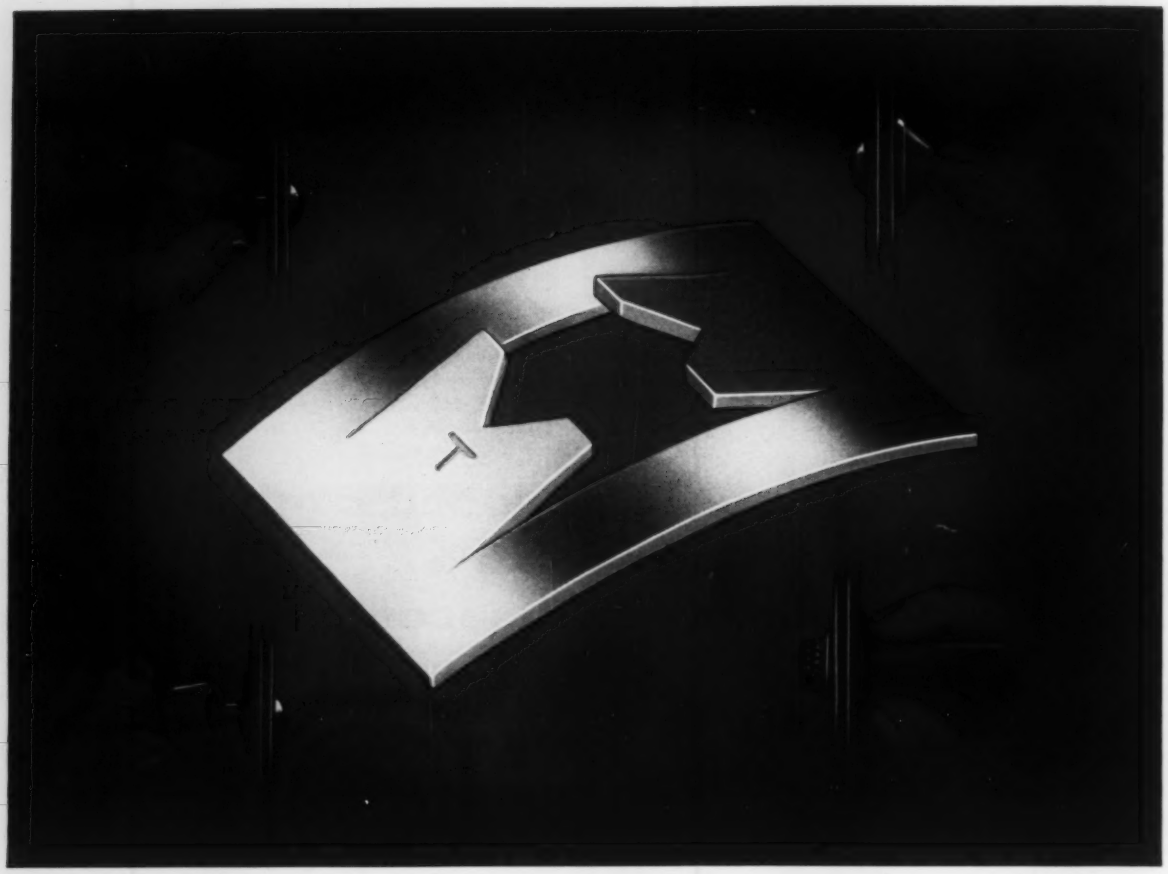
ASD-116



Another Tinnerman Original...

Tinnerman Push-On **SPEED NUTS®** fasten with a "bite" that can't shake loose

In a split-second, this low-cost Tinnerman Push-On SPEED NUT arches its spring-steel back, then bites hard to make a positive attachment on unthreaded studs, rivets, tubing, nails, jewels, small housings.

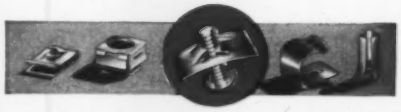
Application is easy—finger pressure starts it; a push with a simple hand tool locks it under live spring tension. No threads to worry about, no spot welding, no riveting, no special inserts, bushings or washers necessary. Elimination of extra parts and assembly operations may save you up to 50% or more in fastening costs.

Push-On SPEED NUTS lock on everything from thermoplastics to die-cast, chrome-plated steel. Hundreds of variations to fit any shape or size stud —from very small diameters to larger rectangular shapes. Some Push-Ons have "caps" that cover exposed shaft, axle or stud ends.

Check Sweet's Product Design File, section 8-T. Or look under "Fasteners" in the Yellow Pages and call your Tinnerman representative for complete information and samples. Or write to:

TINNERMAN PRODUCTS, INC.
Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®

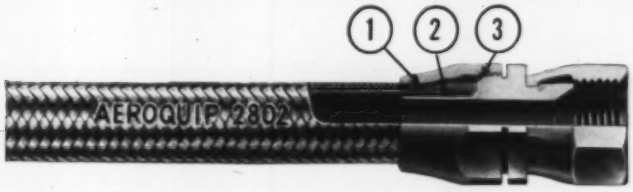


FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Hocaso-Bundy GmbH, Heidelberg.

For Top Performance and Economy . . .

use AEROQUIP HOSE OF TEFLON AND REUSABLE "*super gem*" FITTINGS for all chemical, steam and high temperature fluid systems



This cutaway view shows how Aeroquip patented* "*super gem*" Fitting seals 2802 Hose of Teflon to protect against leakage at all pressures: Compression of wire reinforcement (1) assures positive grip and lasting protection against fitting blow-off. (2) A lip seal is formed by the tube of Teflon seated, but not compressed, between the nipple and sleeve. (3) A metal-to-metal line seal is formed by the mating of the nipple and sleeve.

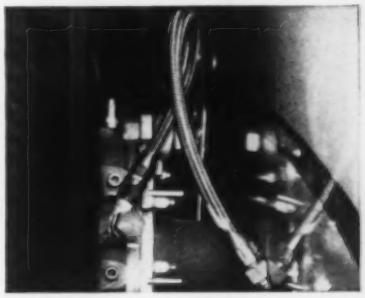
Hose lines of Teflon make possible prolonged service of fluid lines under extreme fluid temperatures or where chemical stability, lubricity and flexing cause design or maintenance problems.

Use of the reusable "*super gem*" Fitting on Aeroquip 2802 Hose of Teflon assures top performance and economy. This unique Fitting provides permanent protection against leakage, yet detaches quickly for modification or reuse on a new hose. Only bench tools are needed to assemble or disassemble any 2802 Hose Line.

FLEXIBLE HOSE OF TEFLON replaces steam pipe with leaking swivel joints to eliminate constant maintenance problem on this tire curing mold. Hose line was made by assembling Aeroquip 2802 Hose and "*super gem*" Fittings in plant, using ordinary bench tools.

STEAM LINES under constant 100 psi. pressure flex 2000 times a day on this laundry pressing equipment. User reports leakproof performance with Aeroquip 2802 Hose of Teflon, even after months of service.

GOOD LUBRICITY of Aeroquip 2802 Hose assures quick drainage and flushing of paint spray lines and transfer or processing lines.

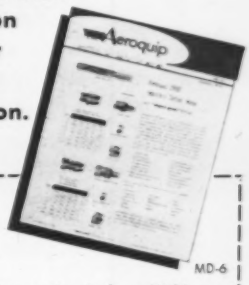


LOW VOLUMETRIC EXPANSION of Aeroquip 2802 Hose of Teflon makes it ideal for braking or actuating systems. Installation seen above is front wheel hydraulic brake line on winning car of Indianapolis '500' race.

CHEMICAL STABILITY AND INERTNESS of 2802 Hose of Teflon above are proved in more than a year's service conveying methylene chloride, solvents and aerosol products. Detachable "*super gem*" Fittings of corrosion-resistant stainless steel match hose durability.

AIR COMPRESSOR DISCHARGE LINE is made of 2802 Hose of Teflon to resist effects of heat buildup and vibration. Service life of Hose is practically unlimited in this and many other applications with temperatures up to 500° F.

Fill in and mail the coupon below for complete information.



MD-6

Aeroquip Corporation, Jackson, Michigan

Please send me Industrial Engineering Bulletin IEB-268 on reusable "*super gem*" Fittings and Hose of Teflon.

Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____

Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

INDUSTRIAL DIVISION, VAN WERT, OHIO • WESTERN DIVISION, BURBANK, CALIFORNIA
AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO

Teflon is DuPont's trade name for its tetrafluoroethylene resin
"*super gem*" is an Aeroquip trademark. *U.S. Patent Nos. 2,833,567 and 2,731,279

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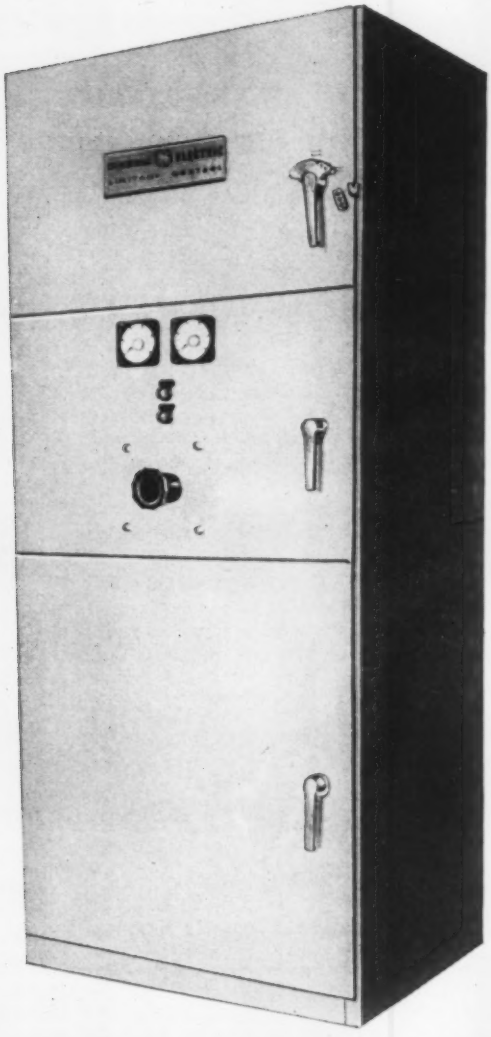


G-E LIMITAMP CONTROLLERS offer users coordinated control for high voltage motors, 2300-4600 v, up to 3000 hp. They are ideally suited for the control of squirrel-cage, synchronous, wound-rotor and multi-speed motors on power systems requiring high interrupting capacity for maximum short-circuit protection.

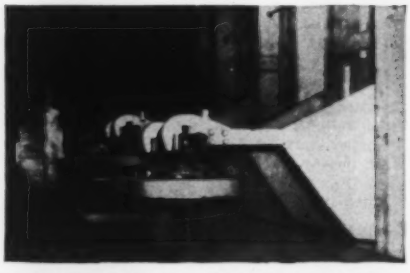
ACP Dip Granodine Process has improved finishes, cut rejects materially on control enclosures

The Industry Control Department of General Electric Company, Roanoke, Va., was looking for an improved method in finishing the steel cabinets and framework for its various control enclosures, such as the Limitamp* panel shown above. An improved prepaint method was needed in order to obtain the high-quality finished paint job required on the enclosures.

General Electric contacted an ACP representative for consultation. He surveyed the operation and at his recommendation ACP Dip GRANODINE 20 was adopted to replace the process in use. The result has been finishes of a clean smooth appearance, besides improved corrosion resistant qualities. In addition, rejects have been materially reduced.

Perhaps you have a similar problem in your finishing department . . . or others that can be solved by using an ACP chemical prepaint treatment. Our application engineers will be glad to help you—feel free to call on us. American Chemical Paint Co., Ambler, Pa.

*Reg. TM of General Electric Co. GRANODINE is a registered trademark of American Chemical Paint Co.



CHEMICAL TREATMENT PROCESSES like ACP Dip GRANODINE 20 used in this Magnus Aja-Lift Automatic Dip Equipment offer improved corrosion resistance, excellent paint adhesion, durable paint finishes.

AMERICAN CHEMICAL PAINT COMPANY, Ambler 44, Pa.

DETROIT, MICH. • ST. JOSEPH, MO. • NILES, CALIF. • WINDSOR, ONT.

CHEMICALS ACP PROCESSES

New Chemical Horizons for Industry and Agriculture

Circle 476 on Page 19

Square D Vertical Action Magnetic Starters Sizes 0, 1, 2, 3, 4 and 5

ONLY SQUARE D GIVES ALL 5

—That's Why You Give Your Customers an Important "Plus" When You Specify Square D Starters

1 *QUICK* INSTALLATION!

No groping or fumbling. Square D provides lots of wiring space, plenty of knockouts, handy and clearly marked pressure wire connectors.

2 *TOP* PERFORMANCE!

No needless downtime from coil burnout, mechanical binding, contact freezing. Square D provides an extra-capacity magnet with a tough and cool-operating encapsulated coil to handle additional poles and interlocks—a guided single moving part—big silver cadmium-oxide contacts with strong finger springs—arcing yokes on larger sizes.

3 *REAL* OVERLOAD PROTECTION!

No change in trip characteristics because of mismatched parts supplied separately for field assembly, no distortion of heater in installation. Square D provides melting alloy unit construction—factory-assembled and individually tested for bull's-eye accuracy. Also bi-metal and magnetic designs for automatic reset or adjustable trip applications.

4 *EASY* INSPECTION and MAINTENANCE!

No starter is "maintenance-free." But Square D makes the job easy. Inspection is a breeze. No need to remove wiring for contact replacement or take the starter out of the enclosure to change coils.

5 *WIDE-RANGE* ADAPTABILITY!

No need for excessive inventories to avoid costly waiting for non-standard arrangements. Square D provides "off-the-shelf" kits for changing contacts and coils, adding pushbuttons, selector switches, and up to 4 double-throw auxiliary circuits.

Send for the COMPLETE Story!

Square D Company, Dept. 44,
4041 North Richards Street, Milwaukee 12, Wisconsin

Please send me your new bulletin with detailed proof that Square D offers me my best starter investment.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

SQUARE D COMPANY

New Design Versatility with RŌTAC

Compact, powerful Rōtac Torque Actuators have a wide range of applications

RŌTAC Rotary Torque Actuators consist of a cylindrical chamber containing a stationary barrier or shoe, and a central shaft with a fixed vane. With fluid or pneumatic pressure applied to either side of the vane, rotary movement in the opposite direction is obtained; power can be doubled by using double-vane shafts. One moving part insures long life and low maintenance.

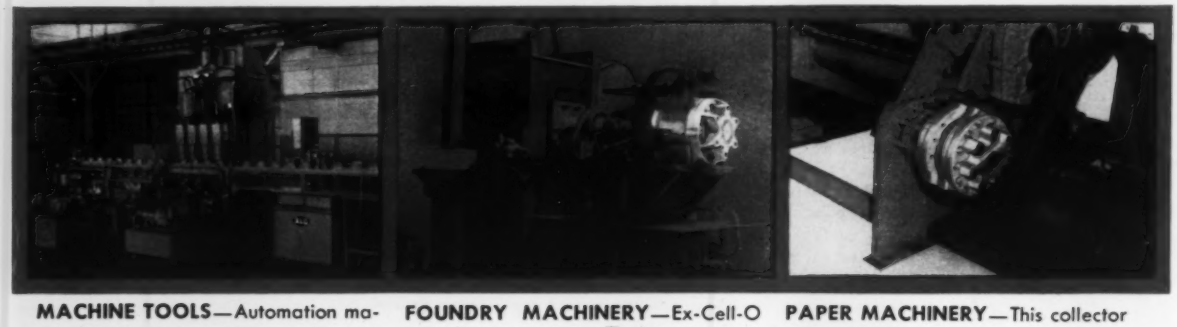
Rōtac Actuators can be mounted vertically, horizontally or at any angle, with the housing held stationary or with the body rotating around the shaft.

Wherever you need motion—powerful, easily controlled rotary action in compact form—Rōtac Actuators simplify design and provide unlimited possibilities for use in various applications.

FREE DESIGN DATA BOOK—20 PAGES

Contains everything you'll want to know about RŌTAC—How it works • Control • Typical applications and special uses • Installation details • Dimensions • Torque ratings • Helpful ideas for using RŌTAC Actuators in your operations.

MOBILE EQUIPMENT—A compact RŌTAC Torque Actuator swings this truck-mounted crane boom in a 280° travel arc; it's controlled through a 4-way valve.



MACHINE TOOLS—Automation machine for boring and grooving piston wrist pin holes uses RŌTAC Torque Actuator for positioning the orienting arbors.

FOUNDRY MACHINERY—Ex-Cell-O Model HN-66-1V RŌTAC Actuators supply the motive power for turnover of the core-box on this semi-automatic shell core blower.

PAPER MACHINERY—This collector roll is actuated by a standard model RŌTAC Actuator which unloads material after a slitting operation is performed.

EX-CELL-O CORPORATION

58-15

GREENVILLE PLANT, GREENVILLE, OHIO

XLO EX-CELL-O FOR PRECISION

EX-CELL-O PRECISION PRODUCTS INCLUDE:
- MACHINE TOOLS • GRINDING AND BORING SPINDLES
- CUTTING TOOLS • RAILROAD PINS AND BUSHINGS
- DRILL JIG BUSHINGS
- AIRCRAFT AND MISCELLANEOUS PRODUCTION PARTS
- TORQUE ACTUATORS • DAIRY EQUIPMENT

Circle 478 on Page 19

why it pays to depend

OFF ON...

1 STANDARD SUBMINIATURE

High capacity—over four times that of most switches its size. Rated at 10 amps at 125 or 250 volts A.C. or 28 volts D.C. Wide range of newly designed actuators . . . or can be adapted to present actuators and mountings. Operating temperature range: —80° to +350°F. Terminal arrangement permits wiring double circuits.

2 NEW TYPE Q SUBMINIATURE

Smallest snap-action switch with a 10 amp—115 volt capacity. Designed for extra vibration resistance and easy installation. Adaptable to automation techniques. Ruggedly built to take up to 100,000 operations at capacity load. Meets a variety of circuit requirements.

3 OPEN BLADE SUBMINIATURE

Use your own housing—even include other components if you desire—with this unique precision switch. Readily adapts to return or set type operation. Actuator may be insulated or extended to meet requirements. Many other combinations are possible.

4 PUSH BUTTON SUBMINIATURE

Three split contact circuits in subminiature size. Only 25/32" long by 55/64" wide by 1 13/64" high. Rated at 10 amps—115 volts A.C. This panel mounted, over-travel plunger-type actuator assembly is believed to be the smallest yet made.

5 OPEN BLADE MULTI-POLE SUBMINIATURE

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Circle 479 on Page 19

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We want to compile a library of case histories on our famous high pressure Ermeto flareless tube fittings. We'll pay you real money to help us accomplish this objective.

Contest Rules

1. This contest is open to everyone actively associated with the design and/or maintenance and operation of equipment in any type or field of industry or commerce including independent design or service engineers. Not eligible are personnel of the Weatherhead Company, its distribution outlets or its advertising agency.

2. At top of first page of each entry must appear contestant's name, home address and phone number; company name, address, phone number.

3. In preparing your entry use only one side of sheet or sheets.

4. Contestant may enter as many different types of Ermeto applications as he wishes but each must be a separate finished manuscript in itself.

5. Contest ends September 30, 1958 and entries must be postmarked no later than midnight of that date.

6. Judging the contest will be qualified graduate engineers of high standing and not associated with Weatherhead Company or its sales outlets. Their decisions will be final.

7. All entries must be based on actual installations backed by factual data which can be fully verified.

8. All entries become the property of the Weatherhead Company.

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1. Your entry will be judged on the basis of how fully it covers all the facts relative to the installation you are describing. It should point up how or why Weatherhead flareless Ermeto tube fittings helped master a problem or achieve greater economy.

2. Drawings of the installation and pictures should accompany your manuscript if at all possible.

3. Unusual applications, excessive pressures or heat conditions, problems of surge or vibration, all are important data for your manuscript.

4. The following is offered as a guide to you in completing your manuscript . . . Type of equipment and its end product or function • Specific supporting function of the Ermeto equipped circuit • Location of equipment • Climatic conditions of equipment area • Restricting factors surrounding equipment • Downtime and maintenance factors • Style and material of Ermeto fittings and number in circuit • Material of connecting tubings • Working pressures • Maximum shock or impulse load • Maximum and minimum working temperatures of circuit • Vibration-maximum deflection factors • Type of hydraulic fluid used • Thickness of tube walls • To what piping specifications does circuit conform • Service life of Ermeto fittings being used • Savings or other economy factors resulting from use of Ermeto fittings.

Mail entries to:

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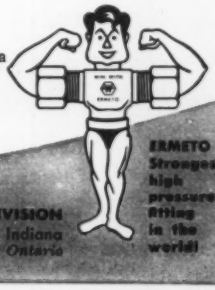

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WEATHERHEAD

THE WEATHERHEAD CO., FORT WAYNE DIVISION
Dept. AB-6, 128 West Washington Blvd., Fort Wayne, Indiana
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MACHINE DESIGN
June 12, 1958

Lifeblood of Design

SOME time ago the late John Jay Hopkins predicted that without revolutionary growth of pure science in this country the day would come when trading in the old car would be useless, because the new one would be no better. And next year's TV receiver would differ from last year's only in the appearance of the cabinet.

Has that day already come? At least part of our current economic slowdown is being blamed on consumer dissatisfaction with changes, masquerading as improvements, which do not fundamentally increase the value of new, more expensive models over the old. So long as the earlier model — thanks to sound engineering — does an adequate job, why trade? There are many other demands on the pocketbook.

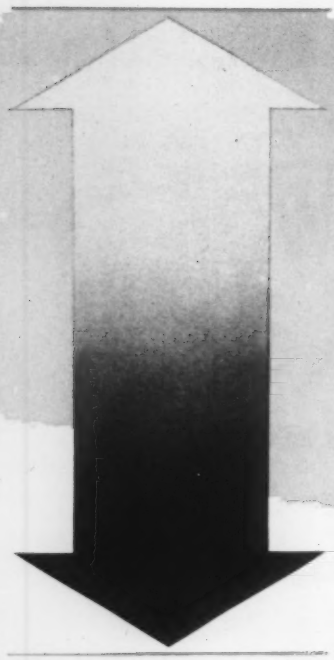
Results of pure or basic research are the principal raw materials of advanced design engineering. Without new knowledge of scientific principles, without new materials, without the findings of "pure" scientists and mathematicians, the creative design engineer is inadequately equipped to develop the hardware necessary to maintain our national security and our economic health in a competitive world.

In their preoccupation with being "practical," even engineers have tended to regard basic research — contrasted with applied — as a frill. Management often considers it an expense which reduces this year's profit with no positive assurance that it will ever pay off. Maybe it is a gamble, but forward-looking businessmen are not usually averse to taking chances. Why the reluctance here?

Design engineers, especially those whose advice is sought by top management, have an opportunity and an obligation to "sell" the idea of stronger support for basic research — the lifeblood of future development. Leadership in engineering can come only from engineers. And we must share the blame for any failure to make our voices heard at the proper time.

Colin Carmichael

EDITOR



THERMAL STRESSES

Part 1—Appraisal of Brittle Materials

By S. S. MANSON
Chief, Materials and Structures Div.
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Cleveland, Ohio

THERMAL stress is induced by temperature effects. When a material is subjected to a temperature gradient, adjacent fibers tend to expand in differing amounts. Constraint prevents individual expansion of each fiber, thus setting up a system of *thermal strains* and associated stresses.

Thermal stress may also occur where no temperature gradient exists if:

1. External constraints prevent free expansion.
2. The part consists of several materials having different coefficients of expansion.
3. Inhomogeneities are present in the microstructure of the material.

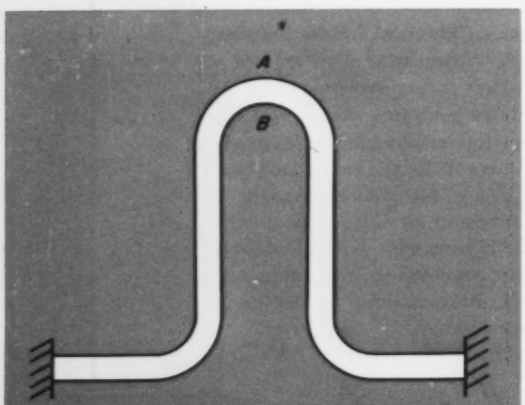


Fig. 1—Tensile stresses due to heating development at point *A* of this typical configuration

Fig. 1 shows a pipe loop, with the ends rigidly fixed, in which tension is produced at point *A* and compression at point *B* when the temperature of the pipe is uniformly increased.

In a bimetallic thermostat element, thermal stress is introduced by the mutual constraint of two metals having different coefficients of expansion. A striking example of material distortion due to internal inhomogeneities, during temperature cycling, is cited by Chiswick.[1] Certain types of uranium rods were found to "grow" and distort appreciably when the temperature was cycled, these effects being due to microstresses generated by the nonuniformity of expansion in all localized regions. Fig. 2 shows the appearance of the specimens, originally 1 in. in length, after 500 cycles of alternate heating and cooling between 50 and 550 C. It can be seen in this case that the smaller the original grain size, the greater the growth.

When the thermal stress is generated by sudden changes in temperature, the action is referred to as *thermal shock*. Sudden changes in environmental temperature, or in internal heat generation—electrical or nuclear—can cause thermal shock. Stresses are determined by temperature distribution, and are little different in thermal shock than they would be if the same temperature distribution could be obtained in the steady-state condition. However, thermal shock stresses are often greater than those due to slow heating and cooling because of the steeper temperature gradients that can be generated.

Another distinction between ordinary thermal stress and thermal shock is that the rate of stress application in thermal shock is very rapid, and

[1]References are tabulated at end of article.

IN DESIGN

- **Failure Criteria**
- **Thermal Shock in Flat Plates**
- **Thermal-Shock Parameters**

High on the list of design problems created by heat are thermal stresses in structural materials. Thermal stresses result principally from unequal expansion caused by temperature gradients. They can lead to catastrophic failure.

Jet, nuclear, and rocket engines all fall prey to such failure. Structures of high-speed aircraft, which are subject to aerodynamic heating, and high-temperature processing plants are similarly threatened.

In more prosaic applications, as well as in these dramatic ones, knowledge about thermal stresses is essential in design. How they originate, how to circumvent them, or how to live with them are questions increasingly demanding adequate answers. The subject is complex, and many facets are still little understood or developed.

However, there exists a substantial fund of information that can be of immediate, practical help to those confronted with thermal-stress problems. This information, including recent developments, is summed up in this series. Emphasis is on those quantitative and qualitative factors which help the design engineer forestall the damaging effects of thermal stresses.

Here, and in subsequent articles, the present state of the art in the following areas is considered: Thermal stress in brittle materials, thermal fatigue of ductile materials, stress computation in the elastic and plastic ranges, thermal-stress measurement, and design considerations.

many materials are affected by the rate of loading. Some materials are embrittled by rapid application of stress and, therefore, may not be able to withstand a shock stress which they could readily absorb if slowly applied. Rapid application of stress also introduces dynamic effects due to accelerations involved during displacement of the various elements of the body.

Although brittle materials may fail in one cycle of thermal stress application, ductile materials usually require a number of repeated cycles before fracture is generated. Failure under repetitive cycling is known as *thermal stress fatigue*, and will be discussed in a future article on ductile materials.

Failure Criteria

Since the failure of brittle materials is not complicated by the occurrence of plastic flow, the criterion for fracture is relatively simpler than for ductile materials. The most commonly accepted theory is that fracture occurs when the normal elastically computed stress, anywhere within the body, reaches a critical value σ_b. Application of this theory permits a simple quantitative approach since elastic stresses can readily be computed for a number of practical cases, and the critical stress for fracture can be measured on specimens of simple geometry.

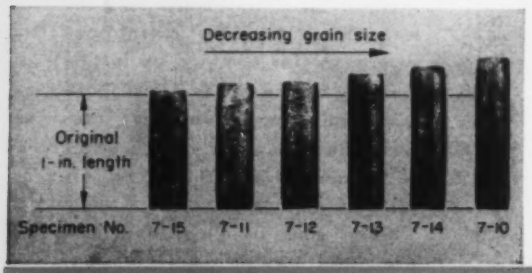
Critical Fracture Stress: The validity of the assumption that failure is governed by a critical fracture stress becomes open to question when this stress is measured during several different types of tests. Measurement of strength in a tensile specimen

often results in values 1/2 to 1/6 those determined in one subjected to a bending stress. While part of this discrepancy may be due to the difficulty in conducting a pure tensile test, devoid of bending induced by load eccentricity, the entire difference in results cannot be attributed to this factor.

Part of the discrepancy arises from different stress distribution in the two types of specimen. In a conventional tensile test the entire volume of material is subjected to the maximum stress. During bending, however, only a fraction of the total volume near the outermost fibers, and only along a portion of the specimen length, is subjected to the maximum stress. The remainder of the specimen is at much lower stress. Weibull[2] has developed a statistical theory of strength based on the concept that flaws exist in the material. Thus the greater the volume under maximum stress, the greater will be the probability of the presence of a flaw at a point of high stress. This concept, in its quantitative formulation, permits accounting for the effect of stress distribution on stress to cause fracture—or, the most probable mean value of a large number of experimental determinations of strength.

Thermal Shock Resistance: The Weibull statistical theory[3, 4] has been applied to the problem of thermal-shock resistance of brittle materials. Results of this study will not be discussed here except to indicate that the strength to be used as the criterion for fracture should be determined by a bending test in which the stress distribution simulates, as closely as possible, the stress distribution developed in the failure region of the thermally shocked specimen. Shown in Fig. 3 is the type of specimen best suited for determining the strength value used in predicting thermal shock resistance of an edge-cooled disc of radius r_m. Comparison of experimental thermal shock resistance with predictions based on such static strength determinations will be discussed later.

Fig. 2—Growth of uranium specimen after 500 thermal cycles. Cycle consisted of a 5-minute hold at 50 C followed by 10-minute hold at 500 C in a sodium-potassium (Na-K) eutectic bath



Thermal Shock in Flat Plates

Most of the prevalent thermal-shock concepts for brittle materials are generalizations of conclusions drawn from the study of a homogeneous, flat plate, initially at uniform temperature, which is suddenly immersed in a medium of lower temperature. This problem will therefore be discussed briefly.

Temperature Distribution: The first problem in any study of thermal shock is to determine the temperature distribution at a time t after the surrounding temperature has been changed. Once this temperature has been determined, the stresses can readily be found in accordance with simple formulas derived from the theory of elasticity. Assuming that the properties of the material do not vary with temperature, and that the material is elastic, the following equation can be written for the stress at any point in the thickness of the plate (see Nomenclature):

$$\sigma' = \frac{T_{av} - T}{T_0} \qquad (1)$$

Physically, σ' can be considered as the ratio of the stress actually developed to the stress that would be developed if thermal expansion were completely constrained. The formula for σ' is

$$\sigma' = \frac{\sigma(1 - \mu)}{E\alpha T_0} \qquad (2)$$

To obtain the surface stress, it is therefore necessary to determine the average temperature and how the surface temperature varies with time. The temperature problem has been thoroughly treated in the literature and the result is usually given in the form of an infinite series. In Fig. 4 are shown the results of some computations that have been made by substituting the exact series solution for temperature into the stress equations.

In the exact solution, there are three important variables. First is the reduced stress, already mentioned, and second, the value β which is equal to ah/k, where a, h, and k are defined in the Nomenclature. The heat-transfer coefficient is defined as the amount of heat transferred from a unit area of the plate surface per unit temperature difference between the surface and the surrounding medium.

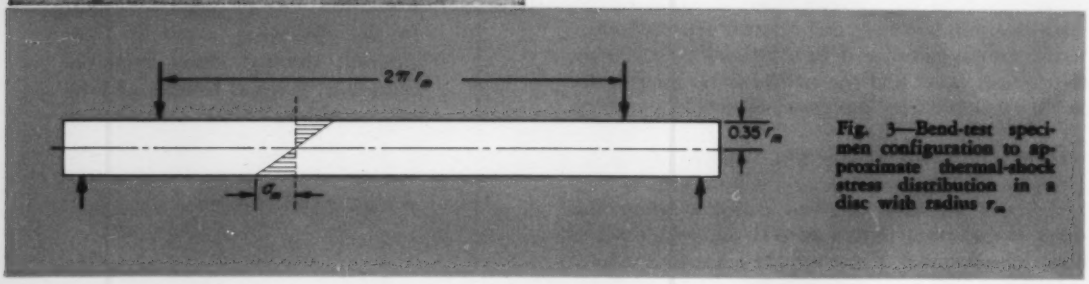


Fig. 3—Bend-test specimen configuration to approximate thermal-shock stress distribution in a disc with radius r_m

The variables a, h, and k always occur as a group, resulting from the manner in which they appear in the differential equation. Therefore, in the generalized treatment of the problem, it is not the individual values of a, h, or k that are important, but their value as grouped together to form the term β. The term β is generally known as Biot's modulus, but in the present discussion it will be called the nondimensional heat-transfer parameter.

The third important variable is θ, which will be called nondimensional time. As shown, $\theta = kt/\rho ca^2$ where the various terms are defined in the Nomenclature. The nondimensional stress at the surface has been plotted as a function of nondimensional time for various examined values of nondimensional heat transfer, Fig. 4. This plot contains the essentials of the entire solution of surface stress in the flat-plate problem. It is simply a matter of replotting to obtain further relations of interest.

Stress Equations: The maximum nondimensional stress at the surface for each value of β can be determined at the peaks of the curves, Fig. 4, and plotted against β, Fig. 5. For many practical purposes, the graphical relation, Fig. 5, is adequate for direct use without regard for the complex mathematical relation it represents. For some applications, however, it is desirable to fit an approximate simple mathematical expression to this curve. Consideration of the boundary conditions for heat-transfer leads to the suggestion that a plot of $1/\sigma'_{max}$ vs $1/\beta$ should be approximately a straight line. For such a plot, Fig. 6, it is seen that for $1/\beta > 0.2$, or < 5, a very good straight line can be fitted to the curve, the equation of the line being

$$\frac{1}{\sigma'_{max}} = 1.5 + \frac{3.25}{\beta} \qquad (3)$$

In the region $\beta > 5$, the curve deviates somewhat from the straight line, bending downward and reaching the limit $\sigma'_{max} = 1.0$ at $1/\beta = 0$, instead of the value 1.5 predicted by the straight line. To make the formula accurate over the entire range, it is

Nomenclature

a = Plate half-thickness
c = Specific heat
E = Elastic modulus
h = Heat transfer coefficient
k = Conductivity
r_m = Radius of disk
T = Temperature at stress point under consideration
T_{av} = Average temperature across plate thickness
T_0 = Initial uniform temperature of plate above ambient temperature (ambient temperature assumed to be zero)
$T_{0,max}$ = Maximum shock temperature withstood
t = Time
α = Coefficient of expansion
β = Biot's modulus or nondimensional heat-transfer parameter
θ = Nondimensional time
μ = Poisson's ratio
ρ = Density of material
σ = Actual stress
σ' = Nondimensional or reduced stress
σ_b = Breaking stress
σ_{max} = Maximum actual stress
σ'_{max} = Maximum nondimensional stress

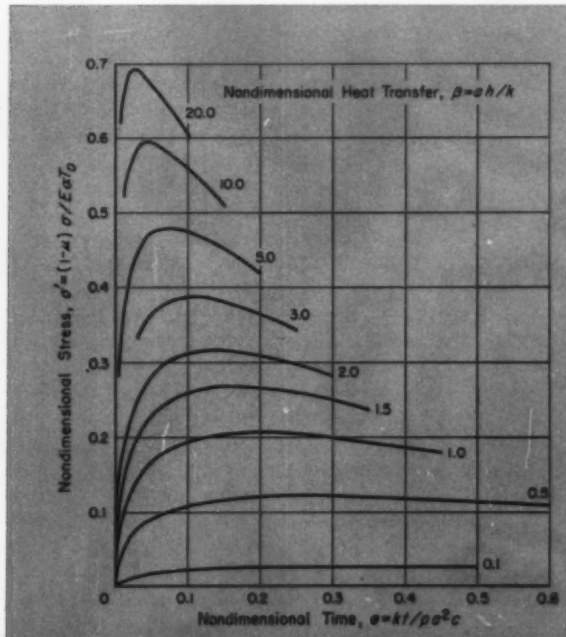


Fig. 4—Dimensionless plot of stress vs. time for various dimensionless heat transfer values

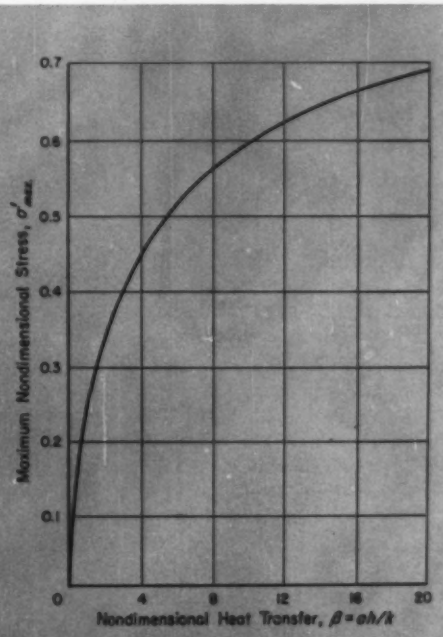


Fig. 5—Dimensionless plot of maximum stress vs. heat transfer

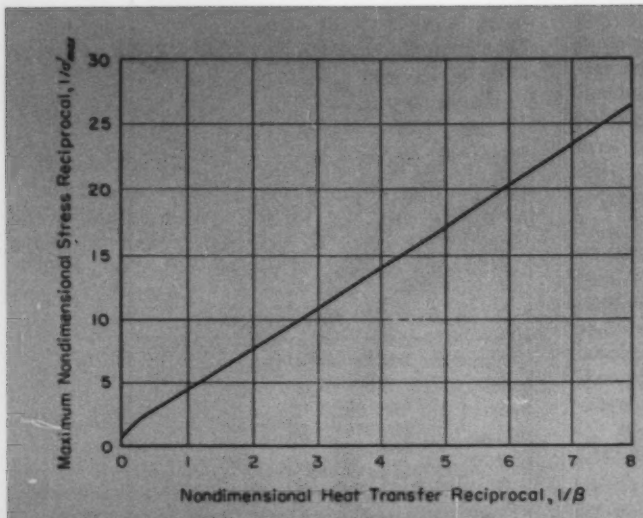


Fig. 6—Above—Relationship between $1/\beta$ and $1/\sigma'_{max}$

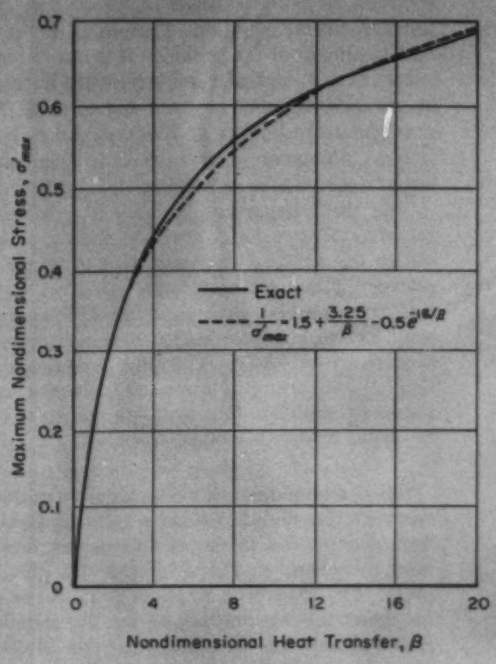


Fig. 7—Right—Correlation of approximate formulas with exact solution for maximum stress

desirable to add a term that will be effective only in the very low range of $1/\beta$ and cause the expression to reach the proper limit at $1/\beta = 0$. An exponential term serves this purpose well over the entire range of β. Therefore, the following equation has been derived relating β and σ'_{max} over their entire range:

$$\frac{1}{\sigma'_{max}} = 1.5 + \frac{3.25}{\beta} - 0.5e^{-16/\beta} \qquad (4)$$

The correctness of fit of Equation 4 and the exact results over a very wide range of values of β are shown in Fig. 7.

▶ Thermal-Shock Parameters

Use can now be made of the approximate formulas to correlate the maximum stress developed in a material with the physical properties of materials.

Small Values of Heat-Transfer Parameter: In most cases, it is found that the value of β for reasonable heat-transfer coefficients, plate thicknesses, and conductivities is relatively low, so that all terms in Equation 4 can be neglected when compared to the value $3.25/\beta$. Then Equation 4 becomes

$$\frac{1}{\sigma'_{max}} = \frac{3.25}{\beta} \qquad (5)$$

or

$$T_0 = \frac{k\sigma_{max}}{E\alpha} \frac{3.25(1-\mu)}{ah} \qquad (6)$$

At failure, $\sigma_{max} = \sigma_b$ = breaking stress; hence,

$$T_{0,max} = \frac{k\sigma_b}{E\alpha} \frac{3.25(1-\mu)}{ah} \qquad (6.1)$$

This equation states that the maximum shock temperature which can be withstood by the plate is proportional to the product, $k\sigma_b/E\alpha$. Since Poisson's ratio μ is similar for all materials, it is placed in the group of terms not involving material properties. This grouping, $k\sigma_b/E\alpha$ is identified as the thermal-shock parameter used by Bobrowsky[5] and others. Equation 6 gives a numerical measure of shock temperature that will cause failure and provides a criterion for listing materials in order of merit.

Table 1 shows results of tests[5] and indicates the order of merit for several materials according to the thermal-shock parameter, $k\sigma_b/E\alpha$. These tests consisted of subjecting a round specimen 2 in. in diameter and 1/4 in. thick to thermal-shock cycles until failure occurred. In this cycle, the specimen was first heated to furnace temperature and then quenched in a stream of cold air, directed parallel to the faces of the specimen. If the specimen survived 25 cycles at one furnace temperature, the furnace temperature was increased 200 F and the tests were repeated. In this way, the temperature was raised until failure finally occurred. Table 1 shows that a good correlation was obtained between the maximum temperature achieved and the thermal-shock parameter, $k\sigma_b/E\alpha$. Actually Bobrowsky used the tensile stress S, instead of the bending stress, σ_b. For the qualitative comparison shown in Table 1, it is probable that little error was introduced. For quantitative predictions, however, serious error could be introduced, since the tensile and bending stress can differ appreciably as previously

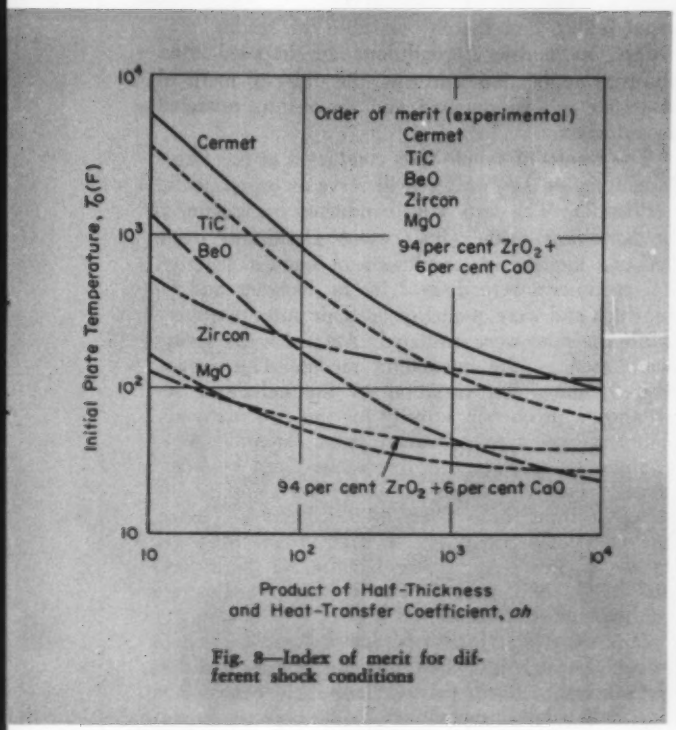


Fig. 8—Index of merit for different shock conditions

discussed in connection with Weibull's theory.

Large Values of Heat-Transfer Parameter: When Equation 4 is again considered, it is seen that, since for large values of β the value $3.25/\beta$ can be neglected compared to the other terms, σ'_{max} becomes equal to unity. It is interesting to examine the meaning of $\sigma'_{max} = 1$ and to determine under which conditions it is achieved. This condition, $\sigma'_{max} = 1$, means that

$$\sigma_{max} = \frac{E\alpha T_0}{1-\mu} \qquad (7)$$

The product, αT_0, is the contraction in the material that would take place if the temperature were reduced by T_0 and the material allowed to contract freely. If contraction is completely prevented by application of stress, than αT_0 is the elastic strain that must be induced in the material to prevent this contraction. This strain, multiplied by the elastic modulus, becomes the stress that must be applied. The term, $1 - \mu$, results from the fact that the problem is for an infinite plate in which equal stresses are applied in two perpendicular directions. The term, $E\alpha T_0/(1-\mu)$, is the stress that must be applied in two perpendicular directions to completely prevent any contraction in the material. Hence, for large values of ah/k, Equation 7 states that the stress developed is just enough to prevent any thermal expansion.

To obtain an index of merit for rating materials under the conditions of a large β, Equation 7 can be rewritten:

$$T_{0,max} = \frac{\sigma_b}{E\alpha}(1-\mu) \qquad (8)$$

This equation suggests that the index becomes $\sigma_b/E\alpha$, and it is seen that the conductivity factor has vanished when compared with the index $k\sigma_b/E\alpha$.

The implication is that it does not matter what the conductivity of the material is; the temperature that can be withstood is proportional to $\sigma_b/E\alpha$. Physically, this result can be understood by examining the meaning of large β, which condition can occur if a is large, if h is large, or if k is small.

If a is large, it means that the test body is large and that the surface layers can be brought down to the temperature of the surrounding medium before any temperature change occurs in the bulk of the body. The surface layers cannot contract, because to do so they would have to deform the remainder of the body, and this cannot be achieved for a large body. Hence, in this case, contraction is completely constrained, and the stress developed is $E\alpha T_0/(1-\mu)$, irrespective of the actual value of the thermal conductivity.

Similarly, for large heat-transfer coefficients h, the same result can be expected. The surface is brought down to the temperature of the surrounding medium before the remainder of the body has had time to respond to the imposed temperature difference. Hence, complete constraint of contraction is again imposed, and the stress developed is independent of conductivity. Finally, if the conductivity is small, only the surface layers can realize

Table 1—Correlation of Material Properties with Resistance to Fracture by Thermal Shock

Materials Evaluated in Thermal Shock (by order of merit)	Thermal Shock Cycles before Failure for Upper Temperatures (F): 1800	2000	2200	2400	Coefficient of Thermal Expansion, α (in./in./deg F)	Thermal Conductivity, k (Btu/in./hr/sq ft/deg F)	Effective Modulus of Elasticity at 1800 F, E (psi)	Tensile Strength at 1800 F, S (psi)	Thermal Shock Parameter, $kS/\alpha E$
Alloy A[a]	..	..	..	..	8.24×10^{-6}	140	0.10×10^{7}	33,300	566,000
80 per cent TiC + 20 per cent Co	25	25	25	25[b]	5.5	240	6.0	34,600	25,200
TiC	25	25	25	17	4.56	240[c]	6.0[c]	17,200	15,100
BeO	25	3			5.1	104	4.28	6,200	2,950
$ZrSiO_4$	1				2.51	11.6	2.4	8,700	1,700
MgO	½				7.69	16–40	1.24	3,100	520–1300
94 per cent ZrO_2 + 6 per cent CaO	0				5.53[d]	14.3[d]	2.5[d]	6,750	700

[a]Not yet evaluated, but probably best of all materials given. [b]No failure. [c]Value for 80 per cent TiC + 20 per cent Co. [d]Value for ZrO_2.

the imposed thermal shock conditions, the remainder of the body remaining essentially at the initial temperature. Again, complete constraint against thermal contraction is imposed and the stress is independent of the precise value of k, providing it is small.

Reversal in the Index of Merit: The previous result, namely, that the index of merit is proportional to $k\sigma_b/E\alpha$ for low values of β and proportional to $\sigma_b/E\alpha$ for high values of β, suggests the importance of the test conditions used to evaluate materials. In Fig. 8, the temperature that the test specimens,[5] shown in Table 1, could withstand is plotted for different values of ah. That is, the curves show what would have resulted if different specimen thicknesses, or different heat-transfer coefficients had been used instead of the values actually used. These curves were obtained from Equation 4, in conjunction with the material properties in Table 1.

It is seen that at the low values of ah (the test condition actually used being represented at a value of ah = approximately 10) the order of merit of the materials is in agreement with the experimental observations. For higher values of ah, the index of merit can be reversed. For example, at a value ah = 80, zircon becomes better than beryllium oxide, and for even higher values of ah, beryllium oxide, which was quite good at the low values of ah, becomes the poorest of all materials. This reversal occurs because beryllium oxide has outstandingly good thermal conductivity, and at the low values of ah, the index of merit takes advantage of this good conductivity. At the higher values of ah, the effect of the good conductivity gradually diminishes until, at high values, the high thermal conductivity has no beneficial effect at all.

Test Verification: The importance of this possibility of reversal of merit index should be emphasized because it strongly suggests that test conditions should simulate, as closely as possible, the intended use of the material. If, in order to obtain more rapid failure and thereby expedite the testing procedure, more drastic conditions are imposed than the true application warrants, the order of merit of materials can be reversed and the results rendered meaningless.

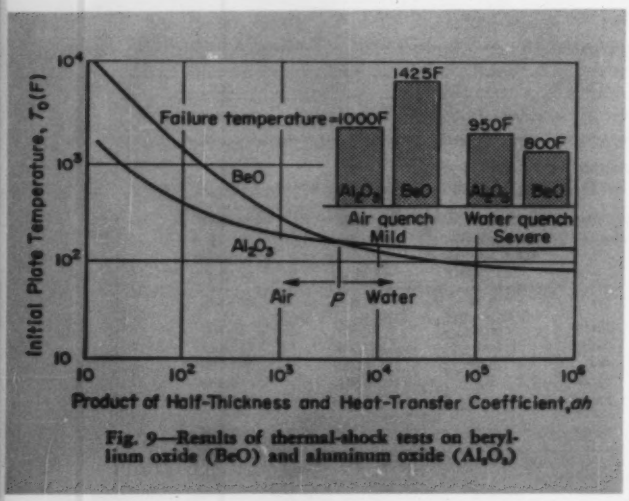


Fig. 9—Results of thermal-shock tests on beryllium oxide (BeO) and aluminum oxide (Al_2O_3)

The results of simple tests conducted at the Lewis laboratory of the NACA[6] will serve as experimental verification. The tests were conducted on specimens of beryllium oxide (BeO) and aluminum oxide (Al_2O_3) under two conditions of quench severity. All specimens were disks 2 in. in diameter and 1/4 in. thick and were quenched on their outer periphery while the sides were insulated. Air and water sprays were used as the quenching media. The curves, Fig. 9, show the variation of thermal-shock resistance with quench severity for the two materials. These curves were obtained from Equation 4 in conjunction with material properties listed by Bradshaw.[7] For BeO these properties were appreciably different from those given in Reference 6. Hence, the curves for BeO, Fig. 8 and 9, are different. However, Bradshaw[7] presents data for both BeO and Al_2O_3, and these data seem to better illustrate the experimental results.

It is seen, Fig. 9, that for low values of ah, BeO is superior to Al_2O_3, but that for severe quenches BeO becomes distinctly inferior. This behavior is due, as previously mentioned, to the high conductivity of BeO, which is of value in improving thermal-shock resistance primarily for mild quenches. At the severe quenches, Al_2O_3 assumes superiority primarily because of its relatively higher breaking strength. The experimental results are shown in the insert, Fig. 9. In the air quench, the superiority of BeO is evidenced by the fact that it withstood any temperature less than 1425 F, while the Al_2O_3 failed at 1000 F. In the water quench BeO became inferior to Al_2O_3, failing when quenched from 800 F, while Al_2O_3 withstood quenching until the temperature reached 950 F.

Because the actual air and water temperatures just before impingement on the specimens were not known, the true quench temperatures are not determinable, but qualitatively, these tests certainly indicate the importance of quenching conditions on the determination of the relative merit of materials in their resistance to thermal shock.

The next article in this series will deal with quantitative thermal shock parameters and short duration thermal shock.

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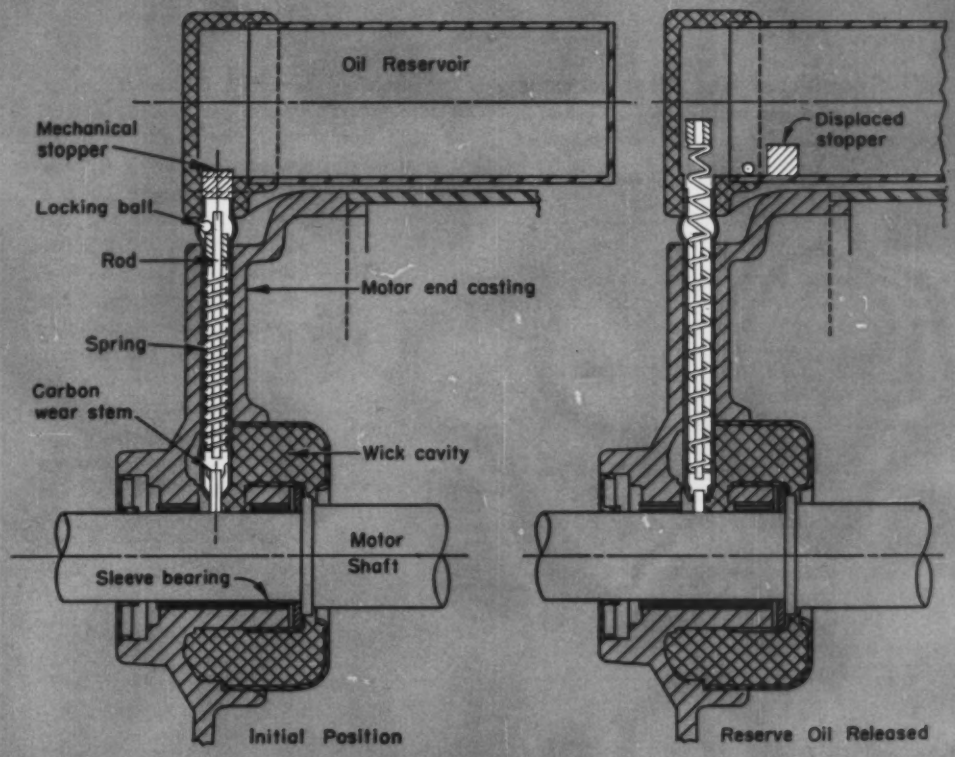
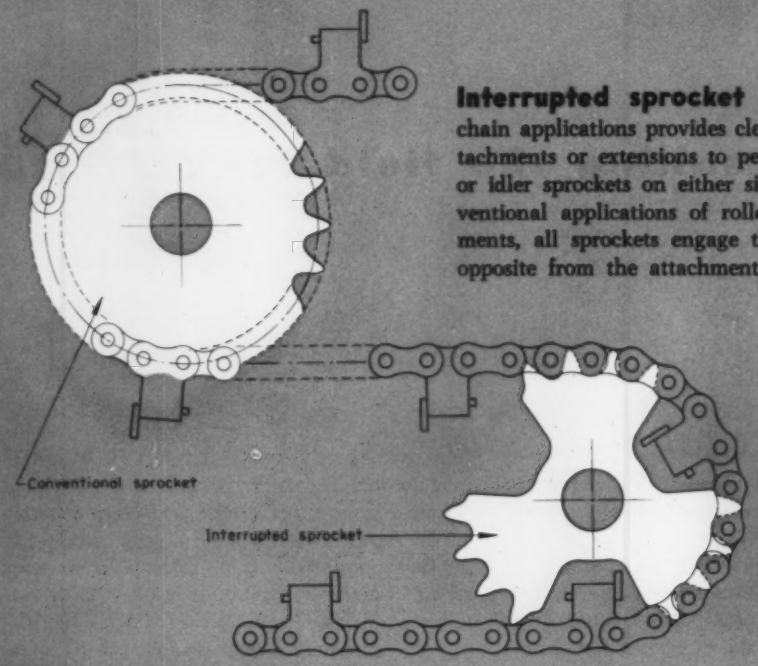
scanning the field for *ideas*

Reserve lubrication system for sleeve bearings has built-in time-delay valve to replenish lubricant automatically after original supply is exhausted. The bearing is equipped with a lubricant reservoir in which oil is retained by a mechanical stopper, preventing loss of lubricant during shipping, handling, or storage. After installation and a predetermined period of operation, the reserve oil is admitted to the bearing.

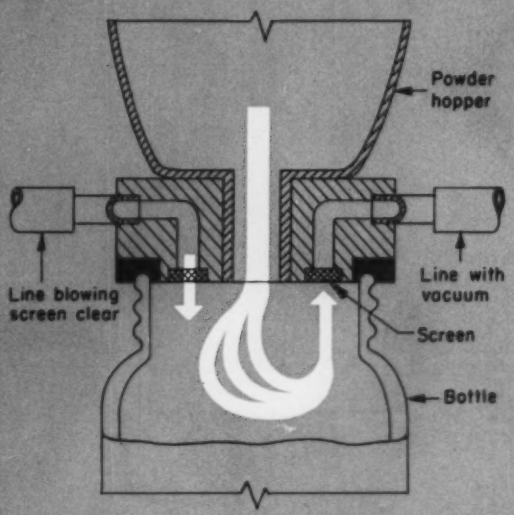
Time-delay feature is provided by a carbon wear-stem which is held against the motor shaft by spring pressure and shortens in length from wear as the motor is operated. When a predetermined amount of wear has occurred, a long rod attached to the wear-stem releases a ball which has acted as a mechanical lock for the opposite end of the wear-stem pressure spring. When the ball is released, it is driven upward by the spring, forcing the mechanical stopper on the oil reservoir out of its seat. With the stopper removed, oil flows from the reservoir to the wick cavity to replenish the expended supply. The design was developed by Franklin Electric Co. Inc. for a fractional-horsepower appliance motor.

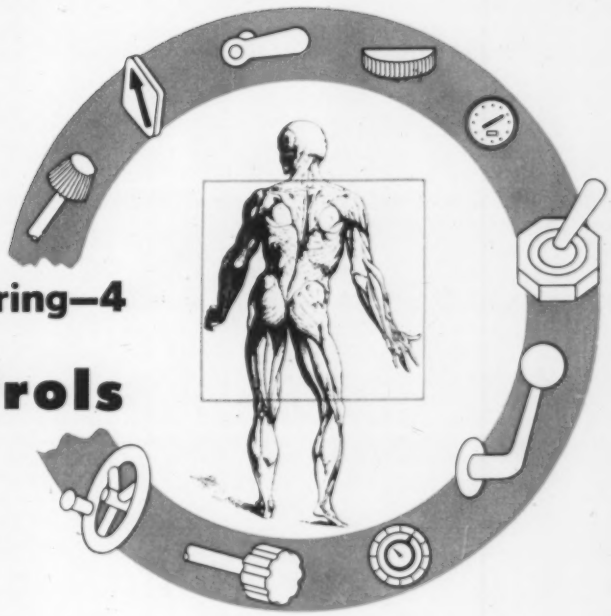




Interrupted sprocket profile for roller-chain applications provides clearance for linkage attachments or extensions to permit location of drive or idler sprockets on either side of chain. In conventional applications of roller chain with attachments, all sprockets engage the chain on the side opposite from the attachments, or the attachments are designed to extend out to the side of the chain to avoid interference with the sprockets. In this design, developed by Crompton & Knowles Packaging Corp., the attachments are designed to meet application requirements and the sprockets are cut out to provide clearance.

Self-cleaning of fine filter screens in "fluid" passages without interruption of flow is achieved by periodic alternation of flow direction through a bifurcated circuit. In a pneumatic system designed to fill bottles with fine powder, the powder is forced to enter the bottle by vacuum techniques. To prevent interruption of the filling cycle, there are two independent vacuum lines, each with a screen. The screens prevent powder from entering the vacuum lines and periodic momentary reversal of air flow blows the screens clear. The reverse flow of one is timed with the middle of the evacuation cycle of the other. The design was developed by Pneumatic Scale Corp. Ltd.





Human-Factors Engineering—4

Design of Controls

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HOW the operator in a man-machine system obtains information by sight and hearing—and what the system designer can do to improve communication between man and machine—were subjects of preceding parts of this series. After receiving and assimilating such information, the operator is often required to take a control action. Whether such action is one of precision, or merely one of muscular effort, selection of the proper control type by the system designer will improve operator accuracy and efficiency.

Table 1—Control-Selection Recommendations

- **Select the control with a motion compatible with that of the display.**
- **Use two-speed controls (coarse plus fine) when high precision is required over a wide adjustment range.**
- **Select the proper ratio of control to display movement.**
- **Use discrete-adjustment controls (detent) rather than those with continuous adjustment when possible.**
- **Use combined controls—the joystick, for example—rather than multiple individual controls when possible.**
- **Select controls that are easily identified with their functions.**

Motion and Precision

General guides can be given to help the control-system designer pinpoint the best type of control for use in a given system application, Table 1. One of the first problems, as noted on the checklist, is to select a control with a motion compatible with that of the resulting display response. Such compatibility is established in the mind of the operator by convention and usage, rather than because one control-movement to display-movement relationship is fundamentally more suitable than another. Applications of linear and rotary controls which generally meet this requirement are illustrated in Fig. 1. The linear control types are representative of a group that includes pushbuttons, toggle switches, levers, and translating or reciprocating pedals. Typical rotary controls are selector switches, knobs, cranks, handwheels, and rotary pedals.

The phrasing of recommendations in Table 1 emphasizes the necessity for the designer to make a careful analysis of system operation before he specifies design details for the various controls in the system. For example, the second item recommends the use of two-speed or multirotation controls when close-tolerance settings are required over a wide

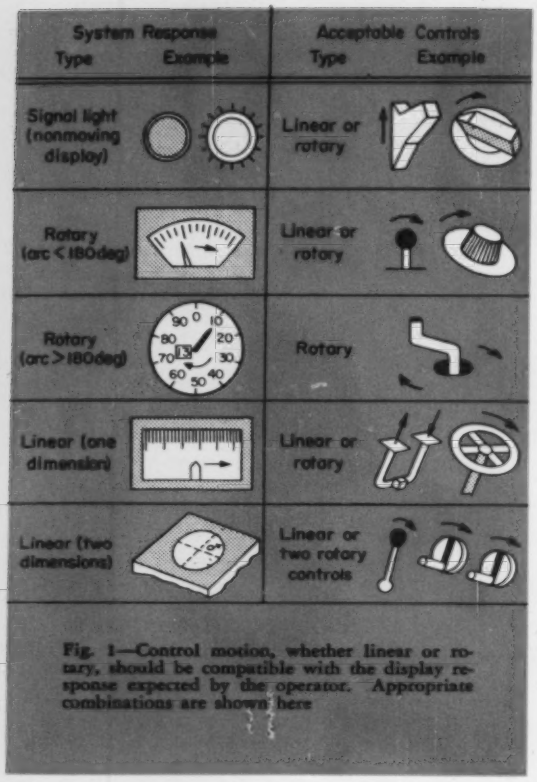

Fig. 1—Control motion, whether linear or rotary, should be compatible with the display response expected by the operator. Appropriate combinations are shown here

range of adjustment. Obviously, it must be determined first whether system tolerances are close enough to demand precision adjustment of controls, and whether settings must be made over a wide range.

Certain elements of the system-control problem fall outside the province of the human-factors engineer. Assume, for example, that a voltage in an electronic circuit must be adjusted to 300 ± 0.3 v. This requires the electronic circuit designer to select a power supply with adequate stability and regulation. In addition, the potentiometer or other voltage-adjusting component must have a resolution and accuracy compatible with the specified 0.1 per cent voltage tolerance.

The human-factors engineer enters at the next stage of the problem. The precision with which a control can be adjusted by an operator is affected by the size of the display giving him information concerning his setting. For a given setting tolerance — ± 0.3 v, in this example—less operator care and attention is required when the adjustment is shown on a large display. This is because the physical distance over which the indicator moves is obviously greater in a larger display.

Similarly, more operator attention is required when the display showing the adjustment is viewed from a relatively great distance, or when time available for making the adjustment is short. Still another factor under the control of the human-factors engineer is the ratio of control movement to display movement. Significant points concerning this ratio are discussed in the following section.

▶ Control-Display Ratios

The desirable ratio of control movement to display movement is affected by display size, setting tolerance, viewing distance, and time allowed for setting. Because each application usually has some unique features, it is frequently necessary to conduct on-the-spot experiments to determine the best control-display ratio.

The relationship of control-display ratio to setting tolerance is easily seen. A large ratio, for example, may be desirable for moving a pointer to the general area of the required setting (the time required to make this part of the setting is called the travel time). The same ratio may be poor for making the final careful adjustment to the required tolerance (the time required to make this setting is called the adjusting time). A satisfactory compromise between such conflicting coarse and fine-setting demands is to provide between 1 and 2 in. of pointer movement for each revolution of the setting knob. When such a compromise has been made, travel and adjusting times will each require about 1 sec, Fig. 2. The total time to make a setting also includes a starting time of about 0.75 sec, which is not included in the values plotted in Fig. 2. Therefore, the shortest total setting time is approximately 2.75 sec for the optimum pointer-movement to knob-rotation ratio.

When the optimum ratio is used, an adjusting time of about 1 sec is required when setting tolerances are specified between 0.012 and 0.019 in. If these tolerance limits are retained, and if 3 to 6 in. of pointer movement are provided per revolution of the control, the adjusting time is increased to between 1.25 to 1.60 sec. If the tolerance is decreased to 0.004 in., adjusting time increases to about 2.4

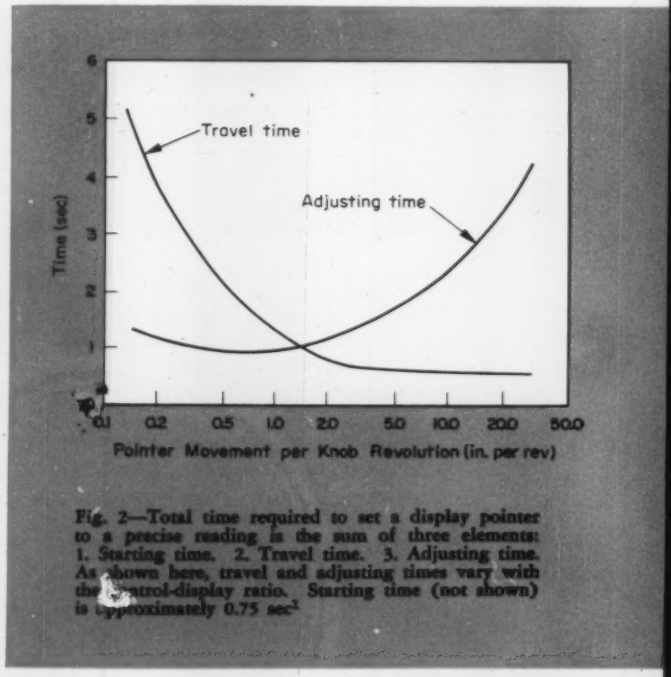

Fig. 2—Total time required to set a display pointer to a precise reading is the sum of three elements: 1. Starting time. 2. Travel time. 3. Adjusting time. As shown here, travel and adjusting times vary with the control-display ratio. Starting time (not shown) is approximately 0.75 sec[3]

sec for the optimum ratio, and to about 3.9 sec for the higher ratio.[1]

The experiments which provided these adjusting-time data were carried out with a relatively small number of subjects. It is to be expected that the data would change if the same study were repeated with more subjects. Nevertheless, such information can be of considerable value, provided that it is recognized that results are approximate.

Adjusting-time data shown in Fig. 2 apply to settings that are made on a scale arranged on a circular dial. On occasion, it may be desirable to arrange the scale in straight-line form and use a lever rather than a rotating knob to make settings. Under these circumstances, the optimum control ratio falls between 1:3 and 1:4. These ratios are expressed in terms of the distance the pointer moves with respect to the distance moved by the tip of the control lever.

If a joystick type control is used, for example, to position a spot on the face of a cathode ray tube, 2½ units of stick movement are suggested for each unit of spot movement.[4]

Kinesthesia

The presence of nerve endings within the muscles makes it possible for man to be aware of the position of his limbs even when he cannot see them. This phenomenon, known as kinesthesis, may be used advantageously by the designer provided he locates controls properly. It has been found, for example, that human operators can locate a point directly in front of their shoulders with an average error of only 1.1 in. Average location errors for targets located at other positions are shown in Fig. 3. To insure that the operator will actuate the proper control, it has been recommended that adjacent controls be separated by at least 5 in. when they are located at shoulder level in front of the operator.[2] The separation should increase as the location of controls departs from the optimum position.

[1]References are tabulated at end of article.

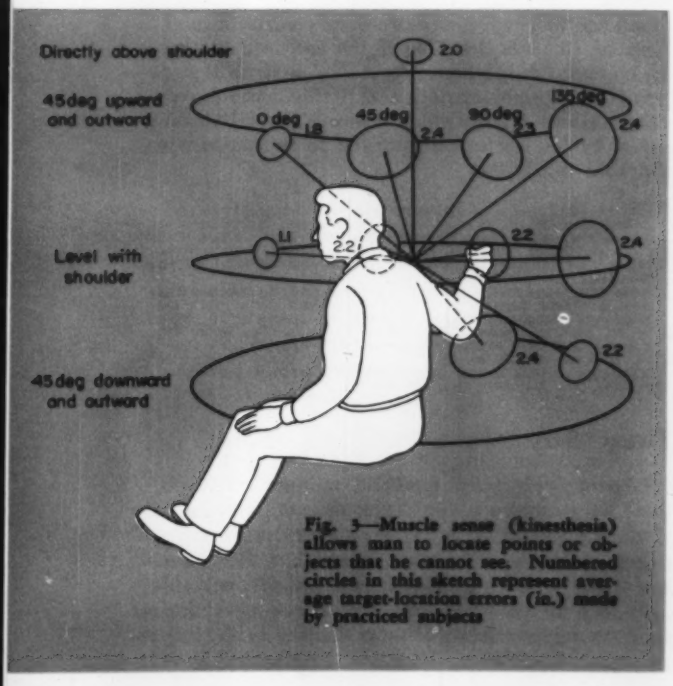

Fig. 3—Muscle sense (kinesthesia) allows man to locate points or objects that he cannot see. Numbered circles in this sketch represent average target-location errors (in.) made by practiced subjects

Control Forces

Recommendations are available regarding the amount of force that should be required of the operator when he must actuate various types of controls.[2,4] For example, when a lever control like that in Fig. 4 is positioned close to the body and is intended to be grasped by the hand rather than by the fingers, the maximum force required for push-pull movements with one hand should not be greater than 30 lb. A force as great as 50 lb is permitted if the control is positioned farther away from the body. When both hands can be used for the operation, about 40 lb appears to be a desirable maximum. When such a control is to be moved in a left-right motion in front of the operator, a 20 lb maximum force should be used for one hand operation and 30 lb for two hand operation.

These forces are obviously considerably below the maximum that can be exerted. In one-hand, push-pull movements, some people can exert a momentary force as high as 250 lb, and a maximum steady pull of 65 lb can be maintained for a longer period of time. For one-hand, right-left motions, about 90 lb is the maximum that can be exerted while the lever is grasped with the right hand and moved toward the left side of the body.

Control by Touch

In selecting controls, the designer can make use of man's ability to discriminate by sense of touch

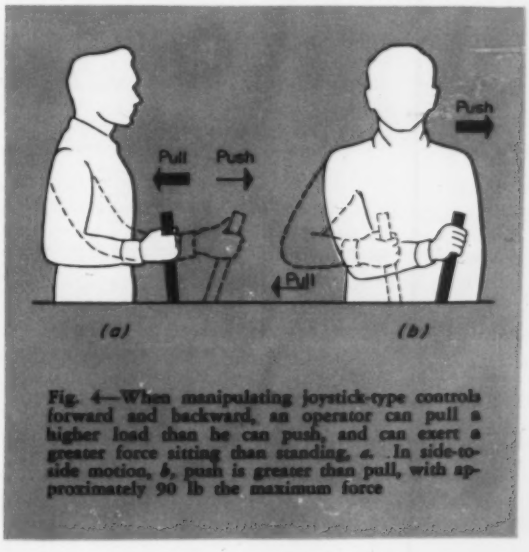

Fig. 4—When manipulating joystick-type controls forward and backward, an operator can pull a higher load than he can push, and can exert a greater force sitting than standing, *a*. In side-to-side motion, *b*, push is greater than pull, with approximately 90 lb the maximum force

among objects that cannot be seen. Research has shown that certain knob shapes are best suited for certain control purposes.

In Fig. 5, for example, class A knobs are suggested for controls that must be spun or twirled more than one full turn, and where it is not important that the operator know the knob position. Class B knobs may be used for controls that are to be turned less than one full turn, and where the position of the knob need not be known by the operator. Class C knobs are suggested for controls which need be turned less than one full turn, and where it is important for the operator to know the knob position. Class A knobs may also be used in those situations in which class B knobs would ordinarily be used. This general rule has a few exceptions: Knob A-3 should not be used with knob B-4; B-1 should not be used with B-5; and B-2 should not be used with either B-3 or B-4.[2]

Control Size and Resistance

Recommendations have been formulated for the best displacement and resistance of specific controls, such as hand pushbuttons, foot pushbuttons, toggle switches, rotary switches, cranks, handwheels, levers, and pedals. Although considerable research has been done on these elements, much of it has been tailored to the needs of a particular design problem, and it is difficult to give firm design suggestions that apply across the board. Specific suggestions reviewed here are intended to serve only as guideposts until additional research can provide more definitive data.[2]

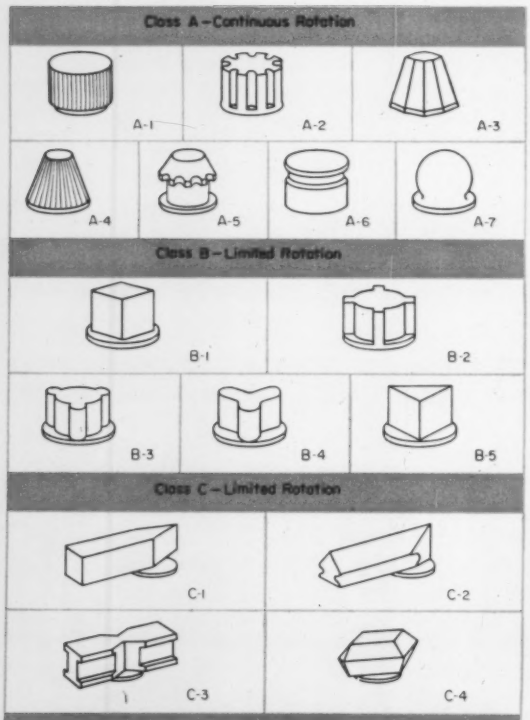

Fig. 5—The "best" knob for a control application depends on two principal factors: 1. Whether it will be turned less than or more than 1 revolution. 2. Whether the operator need know its position. Applications of knobs shown here are described in text

Hand Pushbuttons: A minimum diameter of ½ in. for fingertip operation and ¾ in. for emergency controls that may be operated by the thumb or heel of the hand are suggested for hand pushbuttons. No maximum diameter is imposed by operator performance. Pushbuttons should have a minimum displacement of ⅛ in. and a maximum displacement of 1½ in. for thumb or fingertip operation. For fingertip operation, a minimum resistance of 10 oz and a maximum of 40 oz are prescribed.

Foot Pushbuttons and Pedals: Size, displacement, and resistance are the principal factors in foot pushbutton and pedal design. For the pushbutton, minimum diameter should be about ½ in.; no maximum diameter is imposed by operator performance. A pedal should ordinarily be large enough to permit the operator's foot to rest on it, say, 1 in. by 3 in.

For normal pedal or pushbutton operation, a minimum displacement of ½ in. is suggested, except when the operator may be wearing heavy boots. In this case, a 1 in. displacement is a desirable minimum. For either pedals or pushbuttons, a maximum displacement of 2½ in. is recommended where the control will be operated by ankle flexure only. Where control is by leg movement, maximum displacements for pedals and pushbuttons are suggested as 7 in. and 4 in., respectively.

Minimum resistance recommended for pedals and foot-operated pushbuttons is 4 lb for situations where the foot will not rest on the control; a minimum of 10 lb is desirable if the foot will rest on the control. A maximum resistance of 20 lb is suggested for normal operation of either control type where operation is by ankle flexure. For pedals operated by full leg movement, 180 lb resistance is a desirable maximum.

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They Say . . .

"Apart from fully qualified women engineers, there is great scope for developing the equivalent of the shorthand typist or secretary in engineering, that is, a female technician trained in a fairly narrow field who can nevertheless provide valuable assistance to senior engineers and so relieve them for more important work."—SIR GEORGE H. NELSON, *president, Institute of Electrical Engineers.*

Selection and application of

EPOXY FOAMS

By D. D. SCOTT
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Santa Monica, Calif.

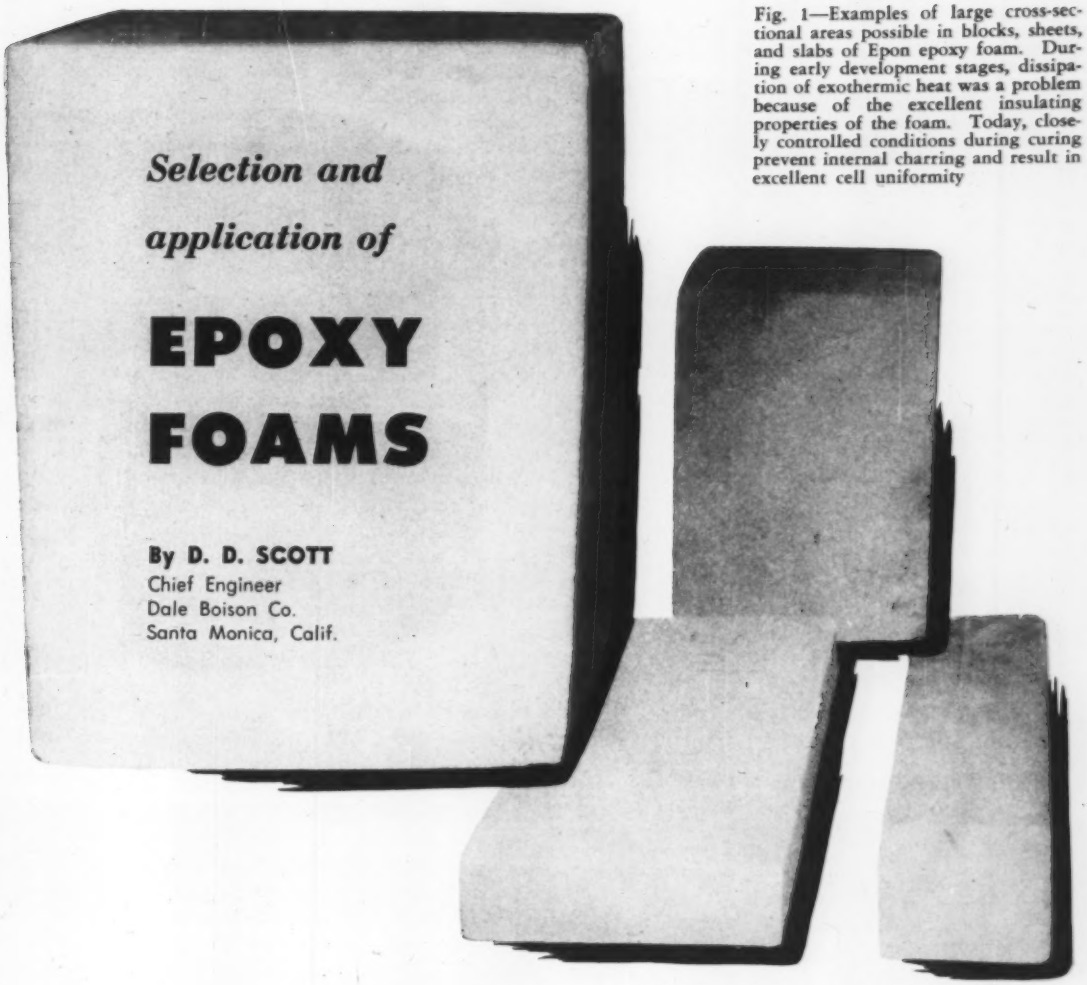


Fig. 1—Examples of large cross-sectional areas possible in blocks, sheets, and slabs of Epon epoxy foam. During early development stages, dissipation of exothermic heat was a problem because of the excellent insulating properties of the foam. Today, closely controlled conditions during curing prevent internal charring and result in excellent cell uniformity

Epoxy foam, although one of the newest of the thermosetting plastic foams, has already found use in many applications which require its particular combination of physical, chemical, and electrical properties. Here is a brief account of its development to date and design factors to be considered in foam selection.

A FOAMED plastic is an expanded, cellular plastic, either rigid or flexible, with open or closed-cell structure. Depending upon application requirements, the liquid-resin formulation can be foamed in place, molded, or pre-expanded into blocks, slabs, and sheets. Plastic foams are used as thermal and electrical insulators, as structural fillers, and in a variety of applications where a combination of light weight and rigidity is required. Mechanical properties of foams vary with type of resin and cell structure, and with density. Physical properties are affected by addition of fillers and pigments.

Properties of Epoxy Foams: One of the newest and most promising of the plastic foams to come out of the laboratory is epoxy foam, which is now available in commercial quantities. Epoxy foams combine the desirable characteristics of cured epoxy resin with the physical properties inherent in hardened foams of the noninterconnected-cell type. They have excellent chemical resistance and dielectric properties, toughness, good adhesive qualities, and a degree of heat resistance which is superior to all thermoplastic foams. Physical, thermal, and electrical properties of epoxy foam are shown in Table 1.

The heat-distortion point of epoxy foam is superior to those of other thermosetting foams with which epoxy was compared. Of the wide variety of fillers available to strengthen epoxy foam, the one most

suited to a particular application must be selected by tests of individual formulations.

Curing: Sheets and blocks of epoxy foam (based on Epon resins) must be oven-cured under controlled conditions to realize fully the high-temperature qualities of epoxy material. Curing-in-place provides excellent adhesion of foam to most metals and materials and is practical if parts can be placed in ovens for prolonged cures. If curing-in-place is not feasible, preformed foam may be readily cut, sawed, drilled, and machined to size before cementing in place.

Methods of Fabrication: Epoxy foams, because of their fine, uniform structure and lack of thermoplasticity, have excellent machinability and do not soften under heat of cutting. Undercuts, angles, and complex contours are easily shaped, and tolerances are comparable to those attained in woodworking.

Potting or encapsulating small components is feasible on a production basis with epoxy foams. To date, successful potting of components to 3 cu in. in volume has been achieved. The most practical foam density for potting is from 4 to 9 lb per cu ft. Mold design considerations include use of a suitable mold-release agent to facilitate removal of parts.

Successful potting depends to some extent on the configuration of the part. A very thin section might prove difficult to cast, although location of the thin section relative to the mold must be considered. Dissipation of exothermic heat may be controlled during foaming and presents no problem. Epoxy-foam blanks have been cast successfully with cross sections as great as 2 ft and with excellent cell uniformity and no charring, Fig. 1.

Table 1—Properties of Epon* Epoxy Foam

Foam Density (lb per cu ft)	Yield Strength (psi)	Coefficient of Expansion† (in./in./deg C)	K Factor (Btu/hr/ft/2 F/in.)	Dielectric Constant	Power Factor
2	100	0.00003	0.20	1.2	0.003
4	100	.....	0.23	1.2	0.003
10	220	.....	0.25	1.2	0.003
20	300	0.00010	0.30	1.2	0.003

*Shell Chemical Corp.
†Range, —30 to +30 C

High-Temperature Properties: Epoxy foam has exceptional dimensional stability. Foamed pieces display complete freedom from warping and excessive dimensional changes on exposure to temperatures to 240 F and high humidity. General-purpose epoxy foams have a heat-distortion temperature of approximately 200 F, but special foams are available which do not soften appreciably at temperatures to 240 F. Current experiments indicate that this limit will soon be raised.

High-temperature resistance of one specially formulated, self-extinguishing epoxy foam was demonstrated with the aid of an acetylene torch. After several minutes of exposure to the torch flame, surface charring resulted but the foam did not burn.

Potting and Encapsulating: Epoxy foam provides an ideal potting compound for electronic components and subassemblies, Fig. 2, if provision is made for heat dissipation other than through the foam. Substantial weight savings can frequently be made by potting with epoxy foam. Completed foam-potted units still meet strength and shock requirements imposed on solid-epoxy encapsulations.

Foams with densities which range from 2 to 20 lb per cu ft are formed and cured in place around electronic circuitry and components inside a plastic or metal case. Electrical properties of the foam package are similar to those achieved with solid-epoxy en-

Fig. 2—Electronic component and mold prior to encapsulation in epoxy foam. Weight savings are achieved by potting in foam rather than in solid plastic, and completed unit is still able to meet strength and shock requirements. Electrical properties of unit remain unaffected

capsulated units. Replacement of components is accomplished more readily with foam-packaged units than with solid-plastic potted units.

Water Absorption: The completely unicellular structure of epoxy foam confines moisture pickup almost exclusively to exposed outer cells. A sample of foam with a density of 3 lb per cu ft was submerged for 48 hr in 8 ft of water and absorbed only one and one-half times its weight in moisture. The foam withstands hydrostatic pressures of 500 lb per sq ft. Water absorption depends on whether the foam structure has a protective outer skin or an exposed cellular layer.

Chemical Properties and Aging: Epoxy foam is noncorrosive to metal surroundings and inserts, is highly resistant to oils and greases, and can be coated with cold-temperature polyester or epoxy skins with no pretreatment, Fig. 3. No apparent significant physical or chemical change was noted in samples observed and tested after a service period of one year.

Comparison of Epoxies With Other Foams: The unicellular structure of epoxy foam is responsible for its excellent thermal insulation properties and buoyancy. However, because of this cell structure, it does not qualify as a good acoustical material. Polyurethanes and phenolics, examples of foams having an interconnected-cell structure, do not have the thermal properties or buoyancy of epoxies but do have superior acoustical properties.

Thermoplastic polystyrene foams, similar in structure to epoxy foams, have the same good properties of thermal insulation and buoyancy. However, polystyrene softens when subjected to slightly elevated temperatures and is nearly liquid at 160 to 180 F.

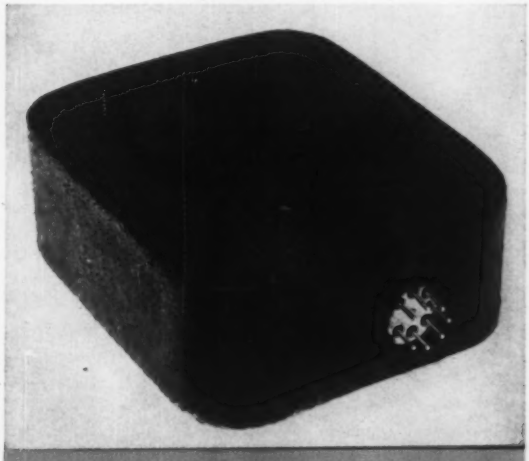


Fig. 3—Epoxy foam coated directly with protective polyester. Foam requires no pretreatment of any kind since the styrene of the polyester does not react with the Shell Chemical Epon

Polyurethane, phenolic, and epoxy foams are all thermosetting and withstand elevated temperatures. At low temperatures, both epoxy and polystyrene foams have superior electrical insulating and dielectric properties. At high temperatures, epoxy foams are superior to the phenolics and polyurethanes because of residuals remaining in the latter two foams.

An outstanding feature of epoxy foam is that it can be coated directly with polyesters without pretreatment of any kind. Styrene foams, however, must be coated thoroughly with an epoxy to prevent the styrene in the polyester from dissolving the foam. Polyurethanes can be coated with polyesters since they are not attacked by the styrene. Some phenolics can be coated easily if the acid residual is not too great.

At present, epoxies are more costly than competitive foams. Applications must require the particular properties inherent in epoxy foams to justify their use. Epoxy foams are still in the development stage for many applications, and price is expected to depend to a great extent on specific applications and density requirements.

Applications: Because of its light weight, rigidity, insulating properties, and ease of preparation, epoxy foams are generally suitable for applications where structural members with high strength-to-weight ratios are needed. Epoxy foams are also used as filler materials to which protective skins are glued, and for thermal and acoustic insulation.

Some potential uses include cores for radomes, fuel-tank baffles, crash-helmet liners, insulation panels for refrigerators, airplane wing cores, lightweight concrete-forms, and tooling applications. Because of low water-absorption, epoxy-foam blanks are intended for use in life preservers, rafts, surfboards, paddle boards, life buoys, and in boats as built-in flotation units.

Tips and Techniques

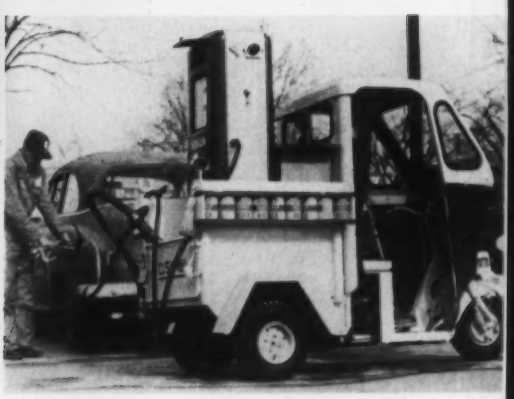
Decibel Measurements

When reducing measurements, such as voltages, to decibel levels, reference to db tables can be avoided by using a slide rule and the definition of the decibel. First, as usual, find the ratio of the measured quantity to the reference quantity. Then, instead of entering this ratio into a table, leave the slide rule set and read the log of this ratio on the L scale. This logarithm is multiplied by 20 for the db value.—JESSE ROTH, *New York, N. Y.*

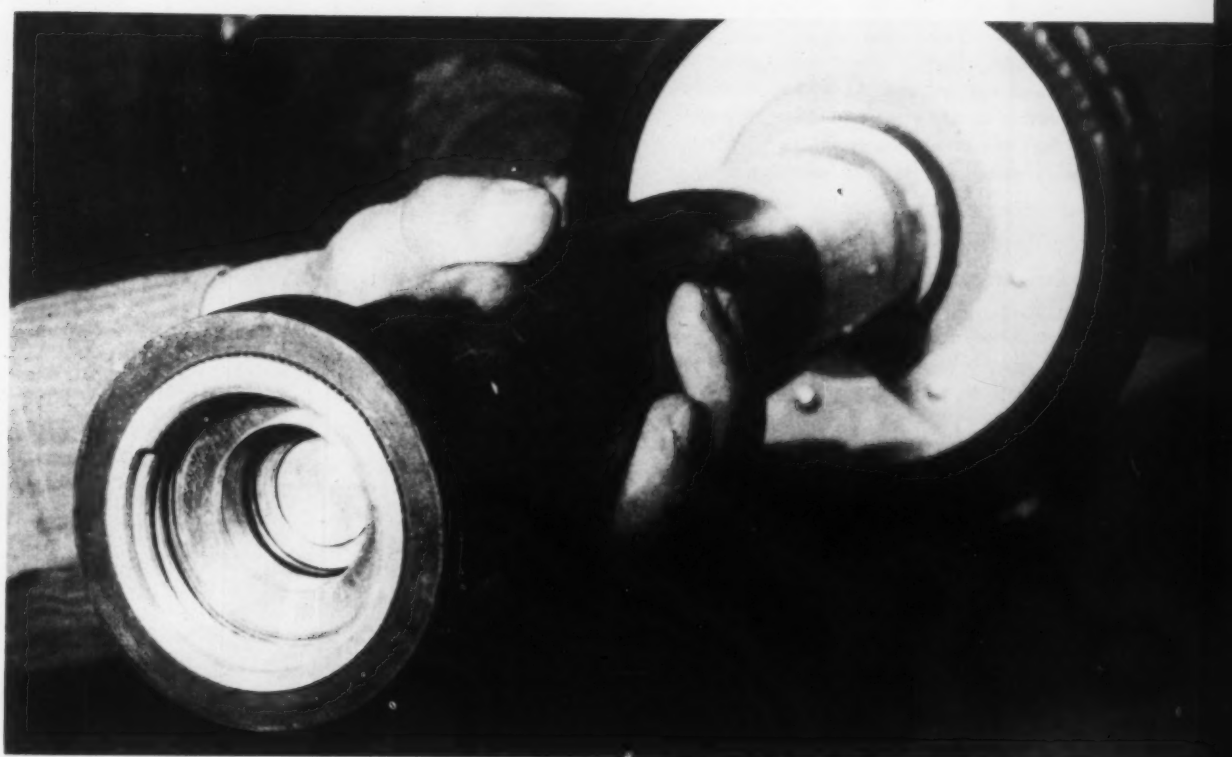
Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Coupling Safely Connects Mobile

COMPLETE SAFETY in dispensing gasoline is offered by a special new quick - connect - disconnect valve coupling made by Snap-Tite Inc., Union City, Pa. The coupling is specifically designed for mobile gasoline dispensing vehicles used by the Kerr-McGee Oil Industries' Shop 'n Gas shopping center in University City, Mo. The "pump," manufactured by Erie Meter Systems, Erie, Pa., is mounted in a three-wheel Cushman truck. The gasoline, which is under pressure in underground storage tanks, is simply metered but not pumped by the dispensing unit. A built-in printer, linked to the metering mechanism, types the customer's bill.



Gasoline "Pump" to Underground Tank



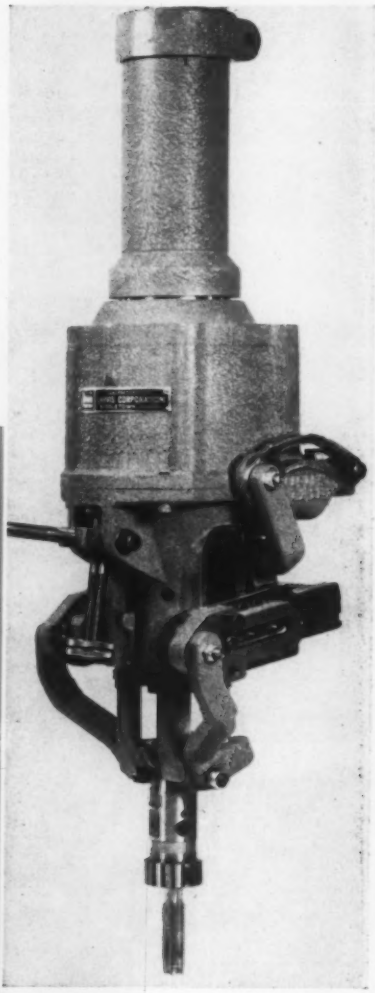
FEMALE HALF of special coupling connects dispenser through a heavy hose to the underground supply. A rubber-tired wheel on this member provides the necessary twisting leverage to lock and unlock coupling to male member.

MALE HALF of valve coupling is built into risers located behind every third parking space. Disconnecting spillage is limited to a small amount of gasoline which clings to the orifices of the coupling valves, thus meeting requirements of Underwriters Laboratory.

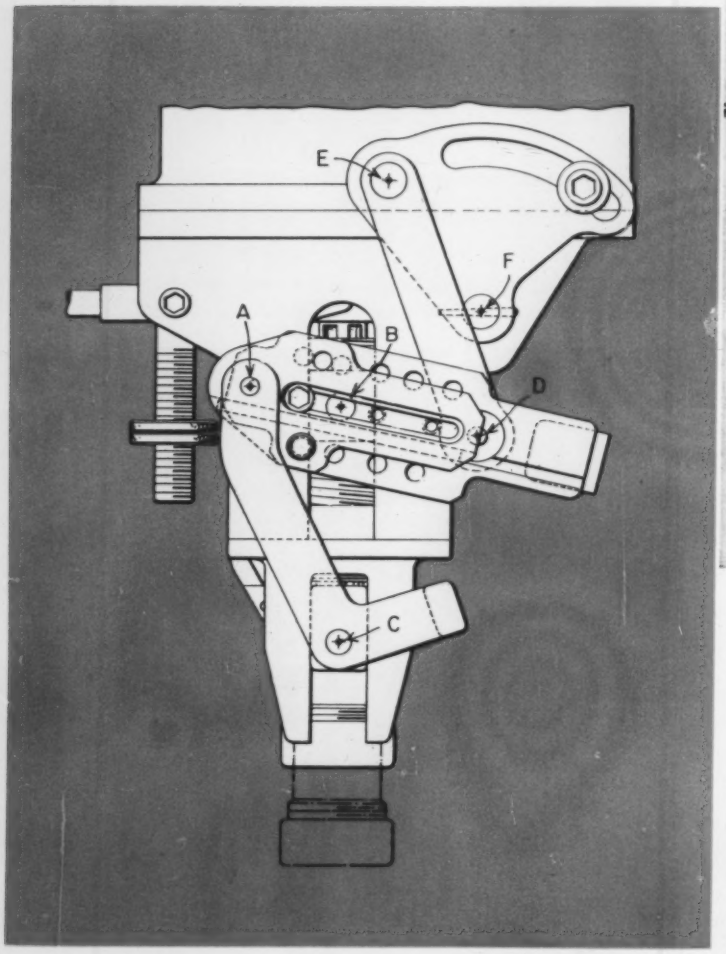
The ground riser opening is protected by double covers. Outer cover is removed by a special tool. Inner cover can be locked in place with integral locking hasp to prevent tampering by unauthorized personnel.

Adjustable Linkage Changes the Pitch in Lead-Screw Tapper

ADJUSTABLE LEAD-SCREW tapper manufactured by the Jarvis Corp., Middletown, Conn., offers cost savings through reduced set-up time and tool storage. As reported by designer George A. Wood Jr., Arthur D. Little Inc., Cambridge, Mass., the adjustable feature in the tapper eliminates stocking a separate lead screw and nut to match the pitch of each tap.



AXIAL RATE OF MOTION of tap chuck determines pitch. Fine pitches require, of course, a slower rate of motion than coarse pitches. If the distance of center slide pivot A from the input point B is changed, the axial motion rate of C is varied while drive speed remains constant. Arm DE provides support for point D and produces at that point a vertical motion component when the projected horizontal length of AD changes. For each length AB, a point E can be found that will provide a uniform output motion of point C for a stroke length well within the limits of tap accuracy.



How to design for tight sealing by specifying the correct

Flange Pressures in Gasketed Joints

By **EARL M. SMOLEY**
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Armstrong Cork Co.
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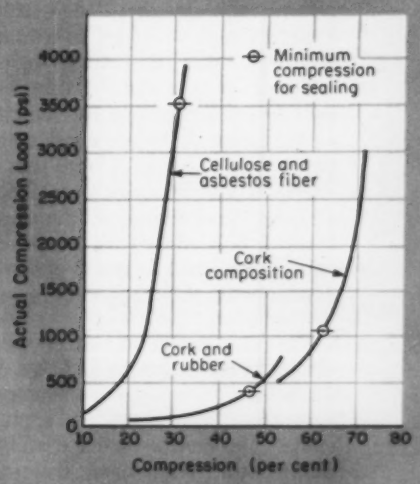


Fig. 1—Load-compression curves for three typical gasket materials of different compositions. Minimum sealing points show degree of compression and flange pressure which must be exceeded if joint is to be tight.

NO SINGLE factor is more critical in the design of a gasketed joint than the initial flange pressure. Unfortunately, little information is available that permits the designer to specify the minimum sealing load for a given gasket material, or to relate this load to flange-bolt torque. Furthermore, because friction always exists between mating screw threads, predicting actual flange pressures from bolt torques is no easy task.

Procedures for handling such design problems have grown out of a research project under way at the Armstrong Research Laboratories. This article presents pertinent findings of the project and gives design suggestions for the following gasket selection and application problems: 1. Significance and use of minimum sealing loads for gaskets. 2. Converting apparent loads (corresponding to bolt-torque settings) to actual compression loads exerted on the gasket. 3. Combining these factors in a manner that is of maximum help in flange design or gasket selection.

Minimum Sealing Loads

Minimum sealing load recommended for any gasket material is the load required to: 1. Effect complete conformance of the gasket with the flange. 2. Make the gasket itself impervious to the sealed fluid. Conformance of gasket and flange is obtained when the gasket is forced by the applied pressure to flow into flange-surface imperfections. The gasket itself presents an impervious barrier to the confined fluid when its porous structure is closed by the compression load.

In any flanged joint, the actual gasket pressure applied should equal or exceed the minimum sealing value recommended by the manufacturer of the gasket material. Sealing points vary widely with the composition and density of the gasket material. Typical minimum sealing loads for three representative materials—cork composition, cork-rubber, and cellulose-asbestos — are indicated by the circled points on the compression vs. pressure curves plotted in Fig. 1.

It is important to understand that the recommended sealing pressure for any gasket material is a minimum load point, not a point of overload. The seal point must be equaled or exceeded by the flange, since higher loads give tighter flange joints. If, for some reason, it is mandatory to impose greater loads on a gasket than those recommended by the manufacturer, no harm is done to the gasket as long as the load is uniformly distributed. In fact, rupture points for typical materials shown in Fig. 1 range upward from 4000 psi.

Apparent vs. Actual Pressure

The difference between *apparent flange pressure*, which is calculated from bolt torque settings, and *actual flange pressure*, exerted by the flange on the

gasket, is due to friction in the bolt threads. Actual gasket loads vary with bolt efficiency and, as a result, the apparent flange pressure calculated for a given design is related to a range of actual flange pressures, rather than to a single value.

Rough, dry, or slightly rusty threads, for example, give low bolt efficiencies. Under such conditions, actual gasket loads are considerably lower than apparent loads because a large part of the applied bolt torque is consumed in overcoming thread friction. On the other hand, if the threads are oiled or greased, bolt efficiencies tend to be relatively high, with the result that actual gasket loads more closely approximate the apparent values calculated from bolt torques.

The plot in Fig. 2, which relates apparent and actual flange pressures, is based on results obtained from study of a number of flange assemblies of the type used in low-pressure applications. They include automotive valve-chamber covers, water pumps, compressor-head flanges, and similar assemblies.

For each assembly studied, the apparent flange pressure was calculated from bolt torque by use of the equation,[1]

$$T = 0.2(DL) \qquad (1)$$

where T = bolt torque, lb-in., D = nominal bolt diam, in., and L = bolt load, lb. When the sum of all bolt loads on a given flange had been determined, the apparent gasket pressure was found as the total bolt load divided by the gasket-flange contact area. Corresponding actual flange pressures were determined by load-compression machines.

The curves in Fig. 2 are a result of a statistical correlation of these apparent and actual flange-pressures data. The dashed line is the statistical least-squares line, and the curved line (design curve) can be considered a confidence curve based on the probability and variability of the data. The confidence curve is also associated with low bolt efficiencies. Typical data obtained for one type of gasket material used in all of the flange designs tested are shown in Fig. 3, along with the corresponding least squares and confidence curves.

[1]References are tabulated at end of article.

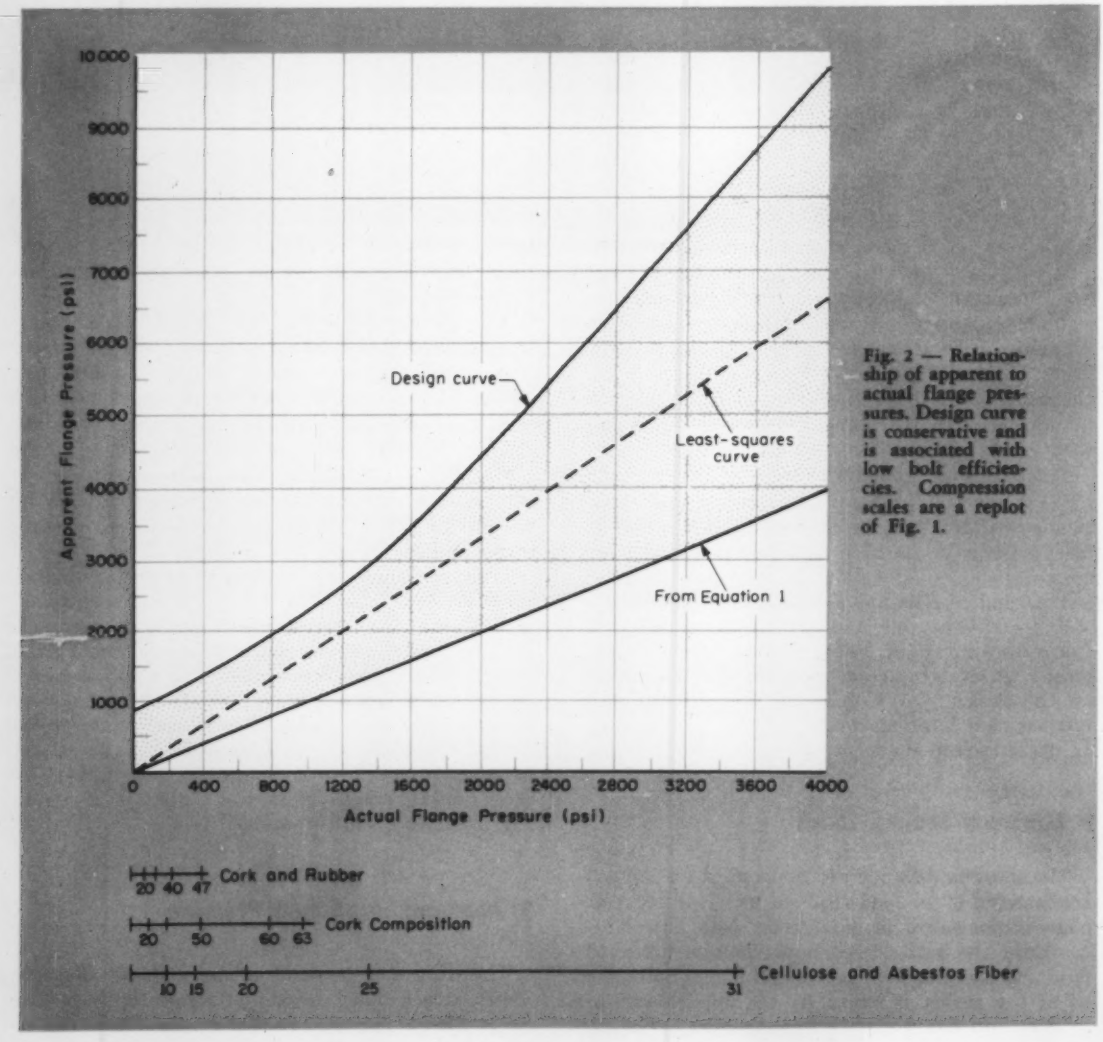


Fig. 2 — Relationship of apparent to actual flange pressures. Design curve is conservative and is associated with low bolt efficiencies. Compression scales are a replot of Fig. 1.

The lower boundary of the shaded area in Fig. 2 assumes the theoretical correctness of Equation 1, that is, *apparent pressure = actual pressure*. Comparison of this curve with the least squares and confidence curves indicates that Equation 1 has assumed clean, lubricated bolts with high efficiency.

Gasket compression scales, drawn as horizontal lines below the actual-pressure axis in Fig. 2, are replots of the compression vs. pressure data given in Fig. 1. Although only three representative gasket materials are shown on Fig. 2, use of gasket manufacturer's data will enable the designer to construct scales for a variety of gaskets meeting almost any requirement in the field of low internal pressures.

Minimum recommended sealing compression for each material (in per cent) is given by the highest compression value noted on its scale. Vertically above this value, the minimum actual flange pressure required for sealing is found on the actual flange pressure axis. For example, 47 per cent is shown as the minimum recommended compression for the cork-rubber gasket material. Directly above this point, 400 psi is seen to be the minimum actual flange pressure that is required to give this degree of compression. The problem of the flange designer is to determine the corresponding apparent pressure.

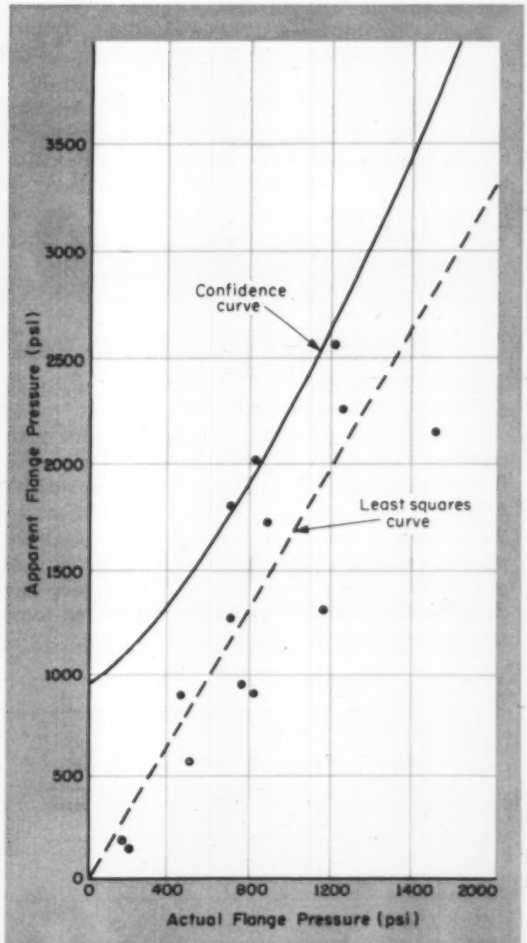


Fig. 3—Typical data scatter obtained in experiments leading to construction of Fig. 2.

Bolt Efficiency

Results plotted in Fig. 2 show why it is possible to speak only in terms of a range of actual flange pressures when apparent pressure is known or calculated. Suppose, for example, that the apparent value given by Equation 1 is 1375 psi. The corresponding actual flange pressure then falls somewhere in the range from 400 to 1375 psi, depending on whether bolt efficiency is very low or equivalent to that implied by Equation 1.

By evaluating the friction in the threads, the designer can estimate in which part of the range actual bolt load is likely to fall. As pointed out in a preceding section, if the bolts are rusty or dry, the actual gasket load will fall in the lower half of the range—nearer the 400 psi value in this example. Clean lubricated bolts, on the other hand, would give an actual pressure closer to the 1375 psi apparent pressure. The straight line plotted in Fig. 2 (least-squares curve) gives a value that roughly coincides with the midpoint between these high and low limiting values.

In practice, use of Fig. 2 is somewhat arbitrary. It is not intended as a substitute for the designer's engineering judgment and experience, but merely as a helpful adjunct. Typical flange-design situations in which the results of Fig. 2 can be applied are presented in following sections. In each example, the flange configuration is assumed to be like the one shown in Fig. 4.

Example 1—Gasket Selection

The basic rule in selecting a gasket for a given flange is that the assembly must operate at or

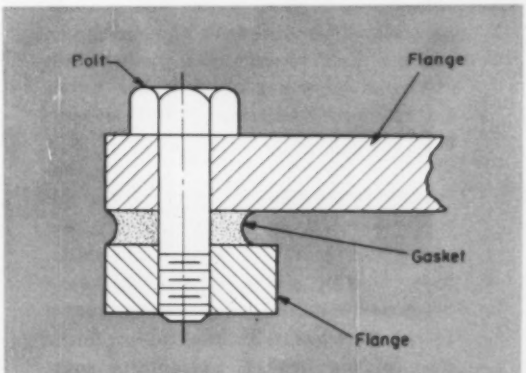
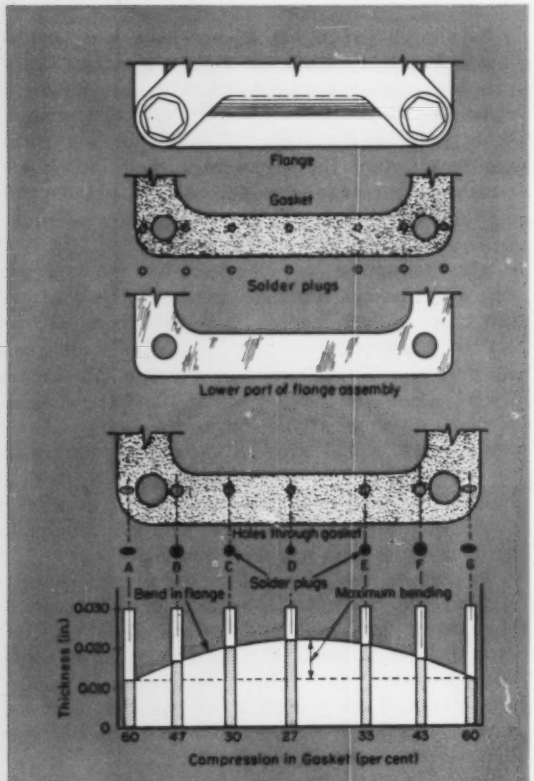


Fig. 4—Flange design assumed for examples in text.

above the minimum seal pressure recommended for the gasket material. To be certain of this, the designer therefore considers only those gaskets with seal points less than or equal to the lower limit of the range of actual flange pressures given by Fig. 2. This lower-limit value is found by first calculating apparent pressure from bolt torque settings, and then entering Fig. 2 with the apparent pressure to find the corresponding actual pressure on the design curve.

Selecting seal points at the lower end of the range means that the designer assumes that the assembly contains bolts of very low efficiency, and therefore produces low actual gasket pressures. Since bolt efficiencies are usually higher than such assumed minimums in practice, there is a high degree of certainty that the flanged assembly will operate above the critical sealing load for the gasket.



SOLDER-PLUG TEST

Gasket compression and flange bending can be checked simply by the solder-plug test. At points where compression values are desired, small holes are punched through the gasket. Soft solder plugs are placed in the holes. Gasket and flanges are then assembled, and each bolt is tightened to a specified torque value. The flange assembly is then taken apart. Since the solder exhibits no elastic recovery, the plugs remain at the compressed thickness of the gasket. From thickness measurements on the compressed plugs, together with the initial thickness of the gasket, percentage compression in the gasket is computed.

▶ Example 2—Flange Design

Where Fig. 2 is used to design a flange for a given gasket material, the problem is to find the number of bolts required in the flange, their diameters, and the torque setting that insures that actual flange loads will never be less than the sealing minimum for the gasket material.

Assume in this example that the flange is to be designed around a cork and rubber gasket with properties like those illustrated in Fig. 1. Minimum sealing compression is therefore 47 per cent and, as Fig. 2 shows, 400 psi is the minimum actual flange pressure required. Again, as a conservative assumption, low bolt efficiencies are assumed, and the corresponding conservative value for apparent flange pressure is given as 1375 psi by the design curve in Fig. 2.

With an assumed gasket-flange contact area of 12 sq in., total apparent load is

$$\Sigma L = 12 \times 1375 = 16{,}500 \text{ lb}$$

The total apparent load is then divided equally among the bolts used in the flange.

It is difficult to give clear-cut rules for determining the number of bolts required for a given flange, principally because of the many variables existing in low-pressure sealing installations. In this example, it is assumed that eight ¼-20 NC mild steel bolts will carry the load without distorting the flange. Each bolt must therefore carry 2063 lb. Equation 1 then gives the required torque setting for each bolt as

Table 1—Flange-Bolt Torque Limits

Bolt Size*	Maximum Torque (lb-ft)
1/4-20	10
5/16-18	15
3/8-16	30
7/16-14	45
1/2-13	60
9/16-12	85
5/8-11	130

*All threads NC

$$T = 0.2 \times 0.25 \times 2063$$

$$= 103 \text{ lb-in.}$$

$$= 8.6 \text{ lb-ft}$$

Torques specified for flange bolts must not be so high that there is possibility of bolt yield or breakage. If this possibility exists, the number of bolts must be increased. If the number cannot be changed, the next larger bolt size must be selected. Table 1 gives approximate torque limits for common bolt sizes used in low-pressure sealing applications. Values listed apply to mild-steel bolts with 0.15 to 0.25 per cent carbon. For harder steels, torque limits can be increased. Table 1 also shows that the approximately 9 lb-ft torque setting calculated for each of the eight 1/4-20 bolts in this example is a safe value.

▶ Measuring Compression

If a more accurate estimate of actual flange loads than is given by the foregoing procedures is necessary, the solder-plug technique can be employed.[2] This method reveals experimentally the degree of compression that results in a gasket when the bolts in an assembly are tightened to a given torque. Reference to the gasket manufacturer's compression vs. pressure data or to Fig. 2 then enables the designer to determine the following information:

1. Actual flange pressure. This is obtained either from a plot of the type shown in Fig. 1, or by direct use of the corresponding bar scale in the lower part of Fig. 2. As in a preceding discussion, actual flange pressure exerted is obtained as the flange pressure directly above the gasket compression value, found in this case by the solder-plug technique.

2. The relationship between the existing compression in the gasket assembly under investigation and the minimum sealing compression recommended for the gasket is revealed by the solder-plug technique. This relationship has obvious advantages in analyzing leakers.

3. Since all compression scales in Fig. 2 are plotted against a common actual flange pressure abscissa, a compression value for one gasket material can be translated directly to a corresponding compression in any other material listed. For example, if the solder plugs indicated 47 per cent compression for the cork-rubber material, the bar scales show that the cork-composition material would be compressed about 55 per cent in the same flange assembly.

REFERENCES

1. W. C. Stewart—"Determining Bolt Tension from Torque Applied to the Nut," MACHINE DESIGN, Vol. 27, No. 11, November, 1955, pp. 209-211.
2. E. M. Smoley—"Gasketed Joints," MACHINE DESIGN, Vol. 28, No. 10, May 17, 1956, pp. 76-78.

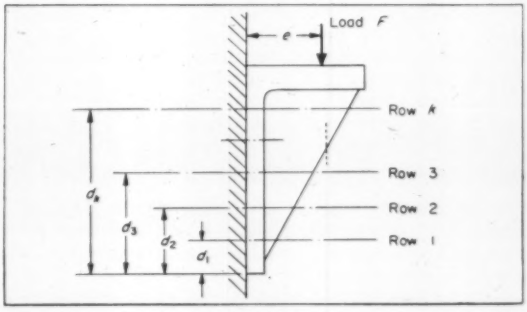
ACKNOWLEDGEMENT

This article is based, in part, on the author's paper "Flange Loadings in Flange Design and Gasket Selection" presented at the SAE Annual Meeting, Jan. 13-17, 1958, Detroit, Mich.

Tips and Techniques

Calculating Bolt Loads

For eccentrically loaded brackets, most texts give a general equation for finding the tension loads on the bolts in any row. In practice, all of the bolts



would be made the same size, and only the most heavily loaded bolt is usually of interest to the designer.

The equation given applies for any number of rows, where n is number of bolts in the row and d the distance from the lower edge. The load on the most heavily loaded bolt is T_k and k is the number of the row farthest from the lower edge of the fastened plate.

$$T_k = \frac{F e d_k}{n_1 d_1^2 + n_2 d_2^2 + \ldots + n_k d_k^2}$$

The same units must be used for T_k and F and also for e and d such as pounds for T_k and F, and inches for d and e.

The shear load should also be checked, since it may determine the bolt size. If the bolts are in clearance holes, the shear load is divided between two bolts, and is equal to $F/2$. If the bolts are fitted in reamed holes, the shear load is equally divided among all of the bolts. If dowels are used, the dowels should be designed for the shear load, and the bolts designed only for the tension load.—J. T. MEIENBERG, *U. S. Rubber Co., New York, N. Y.*

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Impact Forces in Mechanisms

By RAY C. JOHNSON
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Eastman Kodak Co., Rochester, N. Y.

IN HIGH-SPEED machinery, the designer usually wishes to move bodies in as elegant a manner as possible. A great deal of effort is therefore spent in the selection of mechanism proportions and in the development of cam motions. However, for certain limited applications in relatively slow-speed machinery, it becomes dynamically acceptable and economically desirable to utilize mechanisms which are characterized by elastic collisions accompanied by impact forces. Certain pawl and ratchet mechanisms and some mechanical clutches are examples of commonly used mechanisms having impact collisions.

For many years, impact-testing machines of various types have been available for evaluating some of the properties of materials. Also a great deal of literature exists concerning the propagation of stress waves in elastic solid media due to localized disturbances. For many simple cases, mathematical solutions have been obtained. For more complicated cases, experimental techniques have been used for analyzing stress-wave propagations throughout elastic bodies.

Unfortunately, these methods generally do not reveal with any degree of accuracy the stresses which exist at the immediate region of initial disturbance where stresses are generally maximum. Seismic type pick-ups, stress coat, wire resistance gages, and photoelastic studies using streak photography are examples of available experimental techniques. Unfortunately, all of these techniques have serious limitations for original design work.

In design, the aim generally is to hold to a tolerable value the inherently high stress level at the immediate region of contact between two colliding bodies. Under the assumptions of such a design, waves which are propagated throughout the body mass are often at a very low stress level. In fact, for purposes of analysis and design control, it can be very advantageous if colliding bodies are made low in inertia and very rigid in construction, except for an elastic region of contact for absorbing the energy of impact. For such a case, elastic stress waves propagated through the colliding rigid-body masses are insignificant when compared with stresses at the immediate region of contact. Throughout this discussion, attention is

Nomenclature

a, C, k	= Constants
D	= Diameter of sphere in contact with flat plate
E	= Young's modulus of elasticity, psi
F_d	= Propelling or driving force exerted external to driving mass, lb
F_r	= Retarding force, lb
M	= Driving mass, lb-sec^2-in.$^{-1}$
m	= Driven mass, lb-sec^2-in.$^{-1}$
P	= Contact force existing between colliding bodies m and M, lb
P_{max}	= Maximum contact force existing between colliding bodies, m and M, lb
U_c	= Common velocity of both m and M at instant of maximum deformation, in. per sec
V_i	= Velocity of M at instant of initial contact with m, in. per sec
v_i	= Velocity of m at instant of initial contact with M, in. per sec
W_i	= Maximum energy stored in elastic contact region at time of maximum deformation, in-lb
y	= Total deformation of contact region due to contact force P, in.
δ_{max}	= Total maximum deformation at contact region due to P_{max}, in.
ω	= Angular velocity, rad per sec

Impact forces resulting from elastic collisions between rigid bodies are difficult to pinpoint. Here's a simple analytical technique that brackets such impact forces within a "likely" range.

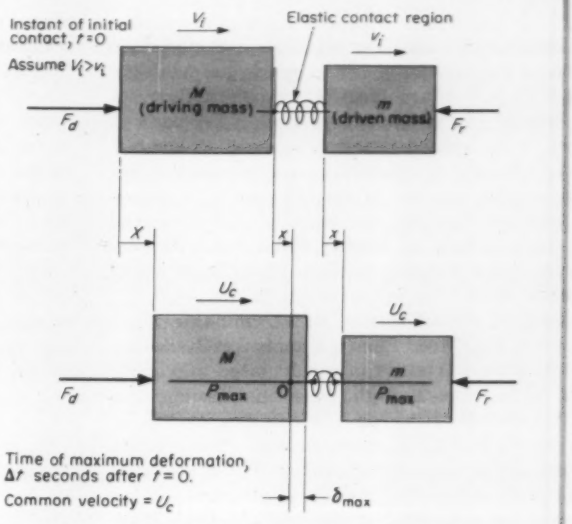

Fig. 1—Rigid bodies in two stages of impact collision. Region of contact is elastic.

confined to collisions between rigid bodies which are separated by an elastic region of contact.

In most practical problems involving elastic collisions, it is impossible to predict accurately what the maximum impact force will be. The purpose of this discussion is to present a method for predicting the likely range wherein the actual maximum impact force will fall, providing certain design suggestions are followed. Therefore, instead of obtaining precise values for the maximum impact force and stresses, the designer obtains likely ranges for these values. Results are generally adequate for many practical problems.

Basic Assumptions: There are several reasons why impact forces cannot be predicted precisely. First, undeterminable flexibilities are generally inherent to supposedly "rigid" bodies. Also, the precise determination of external driving and retarding forces is often impractical as will become apparent from the analysis which follows. Another major source of difficulty can be due to imperfect contact at the impact region, especially where two planes are supposed to be exactly parallel at the instant of contact. Fortunately, this type of a difficulty can be controlled by localizing the stress by use of a spherical surface as subsequently explained. Other sources of error are the very small surface imperfections at the contact region, the existence of mass in the elastic contact regions, and energy losses due to internal and external friction at the contact region.

Throughout the derivations, certain ideal conditions are assumed. Although errors due to these ideal assumptions can be made small by proper design and workmanship, their approximate effects on the analysis should be evaluated by the designer.

One of the most significant possible sources of error can be the presence of mass in the elastic contact region. It is well known that elastic deformations in the form of rapidly moving elastic waves are propagated in the elastic region of contact during the impact collision. These surging stress waves will affect at least slightly the maximum stress in the contact region. Timoshenko and Goodier[1] analyze the case of a rigid mass striking a fixed-end prismatical bar. For a steel prismatical bar, the velocity of wave propagation is approximately 202,000 in. per sec. If the prismatical-bar mass is neglected from maximum impact force calculations, the error decreases as the ratio of rigid-body mass to elastic-region mass increases. Also, the error gives a low value for the calculated maximum impact force.

In this discussion, the effects of these rapid surgings are neglected for several reasons. First, a high ratio of rigid-body mass to elastic-region mass is assumed. This is generally a valid assumption since the colliding bodies can be designed to have a low-mass elastic-contact region and localized stress control can be used as explained subsequently. Thus, most of the impact deformations can be made to occur in the immediate contact region, which is inherently of very low mass. Second, propagation waves generally encounter pinned connections and other nonideal regions where energy losses tend to mitigate the surging waves. Hence, the effects of internal surgings in the elastic region of contact are neglected in this paper. It is assumed that a very high ratio exists for the rigid-body mass divided by the elastic-region mass. This is the case for numerical examples presented here and errors should be very small.

In addition to the neglect of elastic internal

[1]References are tabulated at end of article.

surgings, several other ideal assumptions are made. For example, very small surface imperfections at the contact region can result in maximum contact-force errors which are high or low, depending on the nature of the imperfection. Hence, for control purposes, it is a good practice to have as smooth a surface finish as practical at the contact region. Also, the neglect of energy loss due to internal and external friction at the contact region results in a calculated impact force which is low. However, when contact stresses are kept below the elastic limit, the error is small.

As another simplification, undeterminable flexibilities are neglected. Such an omission is on the safe side, since it results in a calculated maximum contact force which is high. As a final assumption, retarding forces acting on the colliding bodies as shown by F_r in Fig. 1 are neglected. This results in a calculated maximum contact force which is high or low, depending upon the direction of the force and the direction of the body motion. However, retarding forces are generally introduced by friction, and such forces are likely to be small when compared with the impact force.

Impact-Force Range: Two quite different and rather extreme approximations are considered, both lending themselves to relatively simple solution. These approximations define the likely range for maximum impact force. The method of derivation takes into account the very important effect of nonlinear force vs. deflection contact regions which exist frequently in practice. It is also assumed that the force vs. deflection relationship at the contact region is either predictable or known. The method of derivation also takes into account the effect of a propelling force, such as a drive motor, which often is a significant factor.

The first method of approximation is referred to as the *finite-mass assumption*. In this approximation, it is assumed that both the driving body M and the driven body m have finite masses. In addition to the assumed ideal conditions, the driving force F_d is assumed negligible compared with the impact force at the contact region. Under this assumption, the calculated maximum impact force will generally be low because of neglect of the drive-motor effect. The propelling force introduced during the impact period may, of course, be appreciable in magnitude.

The second method of approximation is referred to as the *infinite-mass assumption*. In this approximation, it is assumed that the driving member M has infinite mass, or that its velocity during the impact period does not change. Such an assumption is generally quite severe in that it usually

Example 1

In Fig. 1.1, two rigid bodies are shown at the instant of initial contact. A helical spring with a spring rate of 150 lb per in. exists at the contact region. Body M has a weight of 2 lb and is moving to the right with an initial velocity of 20 in. per sec. An external source of power supplies a propelling force F_d to body M. The exact force vs. speed relationship for this source is unknown, although it is known that force F_d

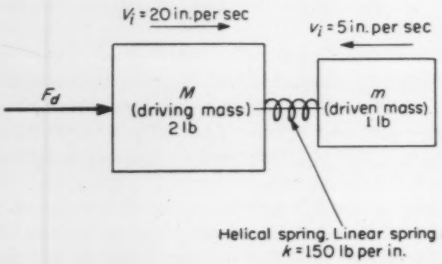

Fig. 1.1—Rigid bodies at instant of initial contact.

increases as speed decreases and vice versa. Body m has a weight of 1 lb and is moving to the left with an initial velocity of 5 in. per sec.

The problem is to determine the likely range for maximum contact force P_{max}.

Solution:

$$M = W/g = 2/386 = 5.18 \times 10^{-3} \text{ lb-sec}^2\text{-in.}^{-1}$$

$$m = w/g = 1/386 = 2.59 \times 10^{-3} \text{ lb-sec}^2\text{-in.}^{-1}$$

$$m/M = 1/2$$

$$k = 150 \text{ lb per in.}$$

$$V_i = +20 \text{ in. per sec}$$

$$v_i = -5 \text{ in. per sec}$$

From the finite-mass assumption, Equation 1 gives

$$U_c = \frac{20 - (5/2)}{1 + (1/2)} = 11.68 \text{ in. per sec}$$

Equation 6 gives

$$P_{max} = \left\{ 150 \left[5.18 \times 10^{-3} \times 20^2 + 2.59 \times 10^{-3} \times 5^2 - (5.18 + 2.59)(10^{-3})(11.68)^2 \right] \right\}^{1/2} = 12.7 \text{ lb}$$

From the infinite-mass assumption, Equation 7 gives

$$P_{max} = \left[20 - (-5) \right] \sqrt{150 \ (2.59 \times 10^{-3})} = 15.6 \text{ lb}$$

Hence, the likely range for the maximum contact force P_{max} is between 12.7 lb and 15.6 lb. If the source of external power has a steep and large F_d vs. speed characteristic, then P_{max} will probably be closer to the 15.6 lb value. On the other hand, if the source of external power has a flat and small F_d vs. speed characteristic, then P_{max} will probably be closer to 12.7 lb.

predicts a maximum impact force which is larger than the actual maximum impact force. Such an extreme impact force could only be attained if the driving mass M were propelled by a driving force F_d with an infinitely steep force vs. speed characteristic, or if the mass M were actually infinite in magnitude. However, neither of these conditions is ever attained in practice. For instance, the torque vs. speed characteristic for an induction motor never attains a vertical slope, even for extremely low rotor resistance.

Both the finite-mass assumption and the infinite-mass assumption are analyzed in detail in following sections. For each assumption, a maximum impact force is obtained, defining a probable range wherein the actual maximum impact force will most likely lie. By considering the characteristics of the particular problem under consideration, the designer can very likely predict which end of the range the actual impact force most closely approximates. The extent to which undeterminable flexibilities exist and the general characteristics of the drive motor are key factors in the making of such an estimate once the range of impact force has been calculated.

Finite-Mass Assumption: In Fig. 1, two rigid

Example 2

In Fig. 2.1, a hardened steel ball, 0.1-in. diameter, moving with initial velocity of 100 in. per sec, is shown about to strike a 6-in. steel cube standing at rest.

The problem is to determine maximum contact force P_{max} and maximum compressive contact stress S_{cmax}.

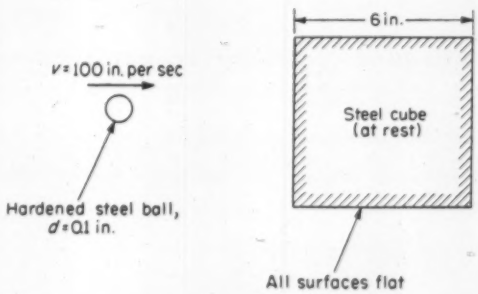

Fig. 2.1—Hardened steel ball propelled against high-mass steel cube.

Solution: From the practical standpoint, the infinite-mass assumption is all that need be considered because of the very large difference in mass between the two bodies. The force-deformation relationship for a sphere striking a flat plate of similar material is given by Equation 8,

$$P = C\, y^{3/2}$$

where C for this special case is given by Equation 11 as

$$C = 0.518\, E \sqrt{D}$$

Hence, for this problem,

$$C = 0.518\ (30 \times 10^6) \sqrt{0.1} = 4.91 \times 10^6$$

For the sphere, the volume is

$$\frac{\pi D^3}{6} = \frac{3.14\ (0.1)^3}{6} = 0.524 \times 10^{-3}\ \text{in.}^3$$

Hence, the weight of the ball is

$$0.283\ (0.524 \times 10^{-3}) = 0.148 \times 10^{-3}\ \text{lb}$$

Therefore, the mass of the ball is

$$m = \frac{w}{g} = \frac{0.148 \times 10^{-3}}{386}$$

$$= 0.384 \times 10^{-6}\ \text{lb-sec}^2\text{-in.}^{-1}$$

Also,

$$V_i = 0$$

$$v_i = 100\ \text{in. per sec}$$

Thus, from Equation 10,

$$P_{max} = \left(4.91 \times 10^6 \right)^{2/5} \times \left\{ \frac{5(0.384 \times 10^{-6})\,(0 - 100)^2}{4} \right\}^{3/5}$$

$$= 19.1\ \text{lb}$$

which, of course, is only an instantaneous force existing at the instant of maximum deformation.

Roark also presents a formula for calculating maximum contact stress from contact force when a sphere contacts a flat plate:[4]

$$s_{c\,max} = 0.616 \left(\frac{PE^2}{D^2} \right)^{1/3}$$

$$= 0.616 \left(\frac{19.1\ (30 \times 10^6)^2}{0.1^2} \right)$$

$$= 740{,}000\ \text{psi}$$

Undoubtedly, a stress of this magnitude is far above the proportional limit for the material, and the value cannot be considered as being precise for that reason. However, contact stresses of this nature are very localized and, in reality, a small brinelled indentation may accompany the impact.

This same problem can be solved by other methods already in the literature. For instance, one commonly used method is based on a linear force-deflection relationship.[5] However, a very large error is introduced when such formulas are applied to nonlinear force-deflection problems. The maximum contact stress for this problem is calculated to be $S_{cmax} = 239{,}000{,}000$ psi by the methods of Reference 5. This calculated stress is far too high because the formula used is based on a linear force-deformation assumption and a linear stress-force assumption, neither of which is valid for this particular problem.

bodies having an elastic region of contact are shown in two stages of impact collision. Fig. 1*a* shows the bodies at the instant of initial contact. It is assumed that each body has an initial velocity, V_i for the driving mass M and v_i for the driven mass m. The direction to the right is considered positive. Driving force F_d, exerted, for example, by a motor on body M, and retarding force F_r exerted, for example, by frictional forces, are both considered negligible compared to contact force P at the contact region between the two bodies.

After a very short interval of time Δt, maximum deformation has occurred at the contact region. This instantaneous stage of maximum deformation is shown in Fig. 1*b*. During the period Δt, body M has moved through a small distance X and body m has moved through a small distance x. The maximum deformation existing at the elastic contact region is denoted by δ_{max}, and at that instant the maximum contact force P_{max} exists.

At the instant of maximum deformation, the relative velocity between m and M is zero. Hence, at this instant, both bodies have identical absolute velocities, denoted by U_c in Fig. 1*b*.

From basic mechanics, the principle of linear impulse and linear momentum may be applied to the problem under consideration. Assuming that $(F_d - F_r)_{avg}$ is negligible and that the time interval Δt is very small, this principle gives the following equation for velocity U_c:

$$U_c = \frac{V_i + \frac{m\,v_i}{M}}{1 + \frac{m}{M}} \qquad (1)$$

The principle of work and energy may be applied to the problem under consideration. Since both F_d and F_r are considered negligible compared to impact force P, and both X and x are small, application of this principle gives W_i, the energy stored in the elastic region of contact at the condition of maximum deformation. The expression is

$$W_i = \frac{1}{2}\left[(M\,V_i^2 + m\,v_i^2) - (M + m)\,U_c^2 \right] \qquad (2)$$

The maximum energy of elastic deformation W_i may be calculated from Equation 2, since U_c can be calculated directly from Equation 1, and it is assumed that M, V_i, m and v_i are known.

Infinite-Mass Assumption: In Fig. 2, a rigid infinite mass M, moving with a constant velocity V_i, is shown about to collide with a rigid body m moving with an initial velocity v_i. The collision occurs at an elastic region of contact as depicted in the sketch. It is assumed that any retarding force F_r is negligible when compared to impact force P at the contact region. This is a valid assumption, since retarding forces are generally limited to frictional forces, which are usually quite small when compared with impact force P.

At the instant of maximum deformation, body m has velocity V_i equal to the constant velocity of the infinite mass. This is apparent since the relative velocity between the two bodies is zero at the instant of maximum deformation.

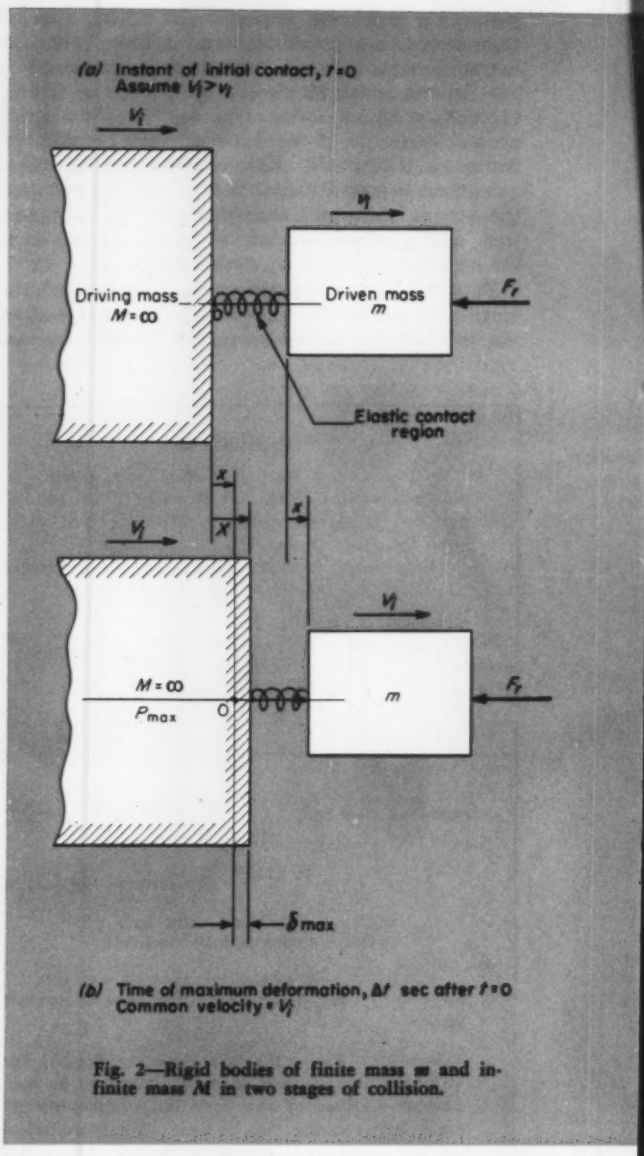

Fig. 2—Rigid bodies of finite mass m and infinite mass M in two stages of collision.

From the known relative motion between the colliding bodies, and by use of the principle of work and energy W_i, the energy stored in the elastic region of contact at the condition of maximum deformation, can be obtained.

$$W_i = \frac{m}{2}\left(V_i - v_i \right)^2 \qquad (3)$$

Energy Stored in a Deformed Elastic Region: Under the finite-mass assumption, the maximum energy stored in the deformed elastic region is given by Equation 2. Under the infinite-mass as-

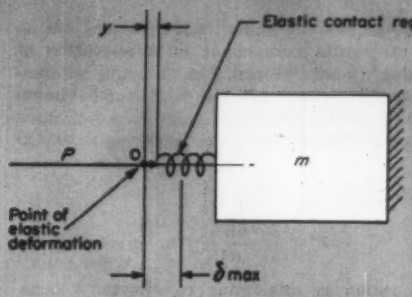

Fig. 3—Deformation of elastic contact region.

sumption, the maximum energy stored in the deformed elastic region is given by Equation 3. Hence, it now becomes desirable to relate the maximum energy stored W_i with the maximum contact force P_{max}.

In Fig. 3, an elastic contact region which is being deformed by a contact force P is shown. The total deformation is denoted by y. When the maximum contact force P_{max} is reached, the maximum deformation δ_{max} exists. For this condition, maximum energy is stored in the deformed contact region.

Work performed by the force P in Fig. 3 equals energy stored in the deformed region of contact, and maximum energy stored in the deformed elastic region is

$$W_i = \int_0^{\delta_{max}} P\,dy \qquad (4)$$

Depending upon the particular problem under consideration, a definite relationship generally exists between contact force P and total deformation y. The proper relationship between P and y can be used in Equation 4 to evaluate the integral.

Linear Deformation at the Contact Region: Often a linear relationship exists between contact force P and total deformation y. Typical examples are found in the deformation of helical springs, extension rods, beams, or columns. Such members are often the elastic regions of contact in impact problems. Contact force P is then related to total deflection y by the spring constant k as follows:

$$P = k\,y \qquad (5)$$

Hence,

$$P_{max} = k\,\delta_{max}$$

and Equation 4 becomes

$$W_i = \int_0^{\delta_{max}} P\,dy = \frac{k\,\delta_{max}^2}{2} = \frac{P_{max}^2}{2\,k}$$

For the finite-mass assumption, therefore, Equation 2 becomes

$$W_i = \frac{P_{max}^2}{2\,k}$$

$$= \frac{1}{2}\left[\,(M\,V_i^2 + m\,v_i^2) - (M+m)\,U_c^2\,\right]$$

Therefore,

$$P_{max} = \sqrt{k\left[\,M\,V_i^2 + m\,v_i^2 - (M+m)\,U_c^2\,\right]} \qquad (6)$$

In Equation 6, P_{max} is the maximum contact force as obtained by the finite-mass assumption for linear force-deflection relationships. In the equation, U_e is obtained directly from Equation 1.

For the infinite-mass assumption, Equation 3 becomes

$$W_i = \frac{P_{max}^2}{2\,k} = \frac{m}{2}\left(V_i - v_i\right)^2$$

Hence,

$$P_{max} = \left(V_i - v_i\right)\sqrt{k\,m} \qquad (7)$$

In Equation 7, P_{max} is the maximum contact force as obtained by the infinite-mass assumption for linear force-deflection relationships. For the case of $v_i = 0$, Equation 7 reduces to the equation presented by Langer which was derived under the constant-velocity concept.[2]

For the case of linear deformations, Equations 6 and 7 define the likely range wherein the maximum contact force P_{max} will fall. The finite-mass maximum contact force from Equation 6 is always less than the infinite-mass maximum contact force from Equation 7.

Nonlinear Deformations at the Contact Region: In general, two nonlinear deformation cases can be distinguished: 1. Curved surfaces in contact. 2. Linear-deformation member contacting a curved member.

TWO GENERAL CURVED SURFACES: When two general curved surfaces are in contact, it can be shown that the contact force P and the total deformation y are related in the following general manner[3]:

$$P = C\,y^{3/2} \qquad (8)$$

In this relationship, C is a constant of proportionality which depends on the radii of curvature of the surfaces at the point of contact, the modulus of elasticity E for the materials, Poisson's ratio for the materials, and a geometric relationship between the curved surfaces defined by Roark.[3]

After substitution of Equation 8, Equation 4 becomes

$$W_i = \int_0^{\delta_{max}} P\,dy = C\int_0^{\delta_{max}} y^{3/2}\,dy = \frac{2\,C\,\delta_{max}^{5/2}}{5}$$

But from Equation 8,

$$P_{max} = C\,\delta_{max}^{3/2}$$

Hence,

$$W_i = \frac{2\,C\,\delta_{max}^{5/2}}{5} = \frac{2\,C}{5}\left(\frac{P_{max}^{2/3}}{C^{2/3}}\right)^{5/2} = \frac{2\,P_{max}^{5/3}}{5\,C^{2/3}}$$

Therefore, for the finite-mass assumption, Equation 2 becomes

(Text continued on Page 146)

Example 3

In Fig. 3.1, a schematic diagram is shown for a pawl and ratchet mechanical clutch. Mass moment of inertia on the drive shaft is is 3.52×10^{-3} lb-sec^2-in., and the drive shaft is externally driven by a single-phase induction motor which exerts driving torque T_d. The drive shaft rotates at an angular velocity of ω rpm.

The driven member has a mass moment of inertia of 1.05×10^{-3} lb-sec^2-in. The elastic region of contact consists of a clutch pawl 0.1 in. by 0.1 in. by 1 in. long with a 1 in. radius spherical contact surface. It is driven by the plane-faced ratchet surface. The spherical contact surface is used to hold the contact stress

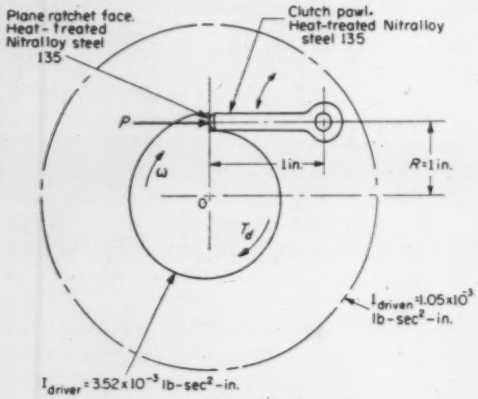

Fig. 3.1—Mechanical-clutch schematic.

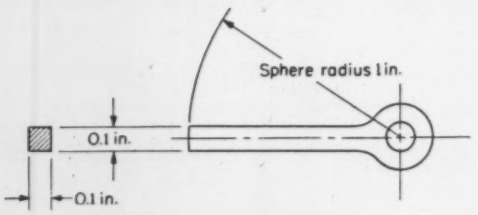

Fig. 3.2—Clutch-pawl detail.

to a predictable value. Localizing the stress in this manner is advisable, since machining errors make it impractical to rely on perfect matching between plane faces. Details of the clutch pawl are shown in Fig. 3.2.

The problem is to determine the maximum angular velocity ω which the driving shaft can have without exceeding a contact compressive stress of 150,000 psi.

Solution: To permit use of the derived equations in this problem, the equivalent two-mass system is considered. In Fig. 3.2, for the driven inertia, Newton's law may be applied. Hence,

$$\sum (\text{Torque})_0 = I_{driven}\,\alpha = I_{driven}\left(\frac{a_t}{R}\right)$$

where α is the angular acceleration of the driven mass at the instant under consideration, and a_t is the tangential component of acceleration at the contact point. From Fig. 3.1, the summation of torques about point O is $P \times R$. Hence,

$$PR = I_{driven}\left(\frac{a_t}{R}\right)$$

Therefore,

$$P = \left(\frac{I_{driven}}{R^2}\right) a_t$$

This equation is analagous to Newton's equation for bodies in translation, or $\Sigma F = ma$. Hence, this implies that an equivalent translational problem is obtained when

$$m = \frac{I_{driven}}{R^2} = \frac{1.05 \times 10^{-3}}{1^2}$$

$$= 1.05 \times 10^{-3} \text{ lb-sec}^2\text{-in.}^{-1}$$

The equivalent driving mass M may similarly be found to be

$$M = \frac{I_{driver}}{R^2} = \frac{3.52 \times 10^{-3}}{1^2}$$

$$= 3.52 \times 10^{-3} \text{ lb-sec}^2\text{-in.}^{-1}$$

The equivalent system for this problem is shown in Fig. 3.3, and the equations of this article can be applied directly to the system. The initial velocity of the mass M will be $V_i = R\omega$, where $R = 1$ in., and mass m is initially at rest.

For the problem under consideration, the elastic region of contact consists essentially of a spherical surface striking against a flat plate backed up by a rectangular parallelepiped. The deformation for a sphere against a flat plate occurs primarily at the localized contact region, and hence the basic formulas apply for the spherical segment at the end of the clutch pawl.

Roark presents a formula for calculating the maximum contact force P_{max} in terms of the maximum compressive contact stress s_{cmax} for the case of a sphere contacting a similar material flat plate:[4]

$$s_{c\,max} = 0.616\left(\frac{P_{max}E^2}{D^2}\right)^{1/3}$$

Therefore, if $s_{cmax} = 150{,}000$ psi, $E = 30 \times 10^6$ psi, Poisson's ratio is 0.3, and the sphere diameter $D = 2$ in., then

$$150{,}000 = 0.616\left[\frac{P_{max}\,(30 \times 10^6)^2}{2^2}\right]^{1/3}$$

Hence, $P_{max} = 64.4$ lb, the maximum contact force corresponding to the maximum contact stress of $s_{cmax} = 150{,}000$ psi.

For the contact region under consideration, the force-deflection relationship is approximated by the general Equation 12,

$$P = C\,y^n$$

where y is the total deformation of the spherical contact region and the rectangular parallelepiped. Values of y will be calculated for $P_{max} = 64.4$ lb, $P = (3/4)P_{max} = 48.3$ lb, $P =$

$(1/2)(P_{max}) = 32.2$ lb, and $P = (1/4)(P_{max}) = 16.1$ lb.

For a given contact force P, the total deformation y equals the deformation of the spherical contact region plus the deformation of the rectangular parallelepiped. For a sphere against a similar material flat plate,

$$y_{sphere} = 1.55 \left(\frac{P^2}{E^2 D} \right)^{1/3}$$

Hence, for $P_{max} = 64.4$ lb,

$$y_{sphere} = 1.55 \left[\frac{64.4^2}{2(30 \times 10^6)^2} \right]^{1/3}$$

$$= 20.5 \times 10^{-5} \text{ in.}$$

For an axially loaded rectangular parallelepiped, the ratio of average compressive stress in the cross section to the axial strain is merely the modulus of elasticity for the material, or

$$E = \frac{P/A}{y_p/L}$$

where y_p is the axial deformation of the parallelepiped and L is the axial length of 1 in. for this problem. Hence, for the rectangular parallelepiped,

$$y_p = \frac{PL}{AE}$$

In this problem $L = 1$ in., $A = 0.1 \times 0.1 = 0.01$ sq in., and $E = 30 \times 10^6$ psi. Thus for $P = 64.4$ lb,

$$y_p = 21.4 \times 10^{-5} \text{ in.}$$

Therefore,

$$y = y_s + y_p = (20.5 + 21.4)(10^{-5})$$

$$= 41.9 \times 10^{-5} \text{ in.}$$

In a similar manner, the total deformations y can be calculated for other values of P. Results of four such calculations are given in Table 1. The four values for P and y are plotted on log-log graph paper in Fig. 3.4.

Table 1—Total Deformation

P (lb)	y_s (in.$\times 10^5$)	y_p (in.$\times 10^5$)	$y_s + y_p$ (in.$\times 10^5$)
64.4	20.5	21.4	41.9
48.3	17.0	16.1	33.1
32.2	13.0	10.7	23.7
16.1	8.16	5.36	13.5

The slope of the straight-line plot is found to be 1.27. As previously explained, this is the exponent a in the general Equation 12. Thus, $a = 1.27$ and the coefficient C can be calculated by direct substitution in Equation 12. Hence,

$$64.4 = C \left(41.9 \times 10^{-5} \right)^{1.27}$$

Therefore,

$$C = 1.28 \times 10^6$$

The elastic contact region force-deflection formula is approximated by placing the values for C and a in Equation 12, or

$$P = (1.28 \times 10^6)\ y^{1.27}$$

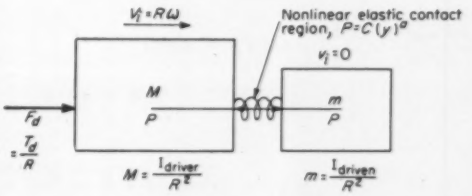

Fig. 3.3—Equivalent system for mechanical clutch.

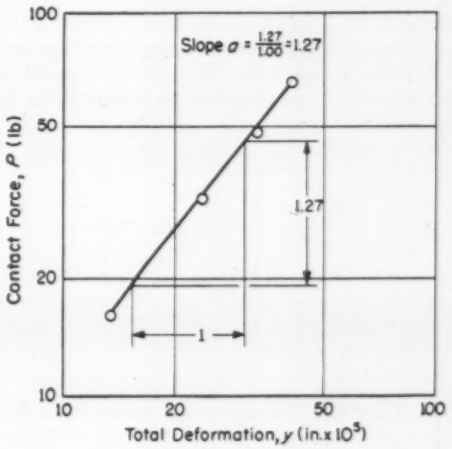

Fig. 3.4—Contact force P vs. total deformation y for pawl-ratchet-face contact region.

In summary, the following values have been found and can be used directly in the derived equations of this article:

$v_i = 0$
$V_i = R\omega = (1)\omega$ in. per sec
$m = 1.05 \times 10^{-3}$ lb-sec^2-in.$^{-1}$
$M = 3.52 \times 10^{-3}$ lb-sec^2-in.$^{-1}$
$C = 1.28 \times 10^6$
$a = 1.27$
$P_{max} = 64.4$ lb

Therefore, from the finite-mass assumption, substitution in Equation 1 gives a common velocity at the instant of maximum deformation of

$$U_e = \frac{\omega}{1.298}$$

After substitution of this value for U_e in Equation 13 together with the summarized values, the finite-mass assumption gives

$$\omega_{max} = 5.45 \text{ rad per sec}$$

$$= 52.1 \text{ rpm}$$

After substitution of the summarized values in the infinite-mass assumption, Equation 14,

$$\omega_{max} = 4.76 \text{ rad per sec}$$

$$= 45.5 \text{ rpm}$$

Therefore, a maximum angular velocity for the drive shaft of approximately 50 rpm gives a contact stress $\leq$ 150,000 psi.

(*Continued from Page* 143)

$$W_i = \frac{2\,P_{max}^{5/3}}{5\,C^{2/3}} = \frac{1}{2}\left[(M\,V_i^2 + m\,v_i^2) - (M + m)\,U_c^2 \right]$$

Thus,

$$P_{max} = C^{2/5}\left\{ \frac{5}{4}\left[(M\,V_i^2 + m\,v_i^2) - (M + m)\,U_c^2 \right] \right\}^{3/5} \qquad (9)$$

In Equation 9, P_{max} is the maximum contact force as obtained by the finite-mass assumption for the force-deflection relationship defined by Equation 8. In Equation 9, U_c is obtained as before directly from Equation 1.

For the infinite-mass assumption, Equation 3 becomes

$$W_i = \frac{2\,P_{max}^{5/3}}{5\,C^{2/3}} = \frac{m}{2}\,(V_i - v_i)^2$$

Hence,

$$P_{max} = C^{2/5}\left[\frac{5\,m}{4}\,(V_i - v_i)^2 \right]^{3/5} \qquad (10)$$

In Equation 10, P_{max} is the maximum contact force as obtained by the infinite-mass assumption for the force-deflection relationship defined by Equation 8.

Equations 9 and 10 define the likely range wherein the maximum contact force P_{max} actually falls. The finite-mass maximum contact force from Equation 9 is always less than the infinite-mass maximum contact force from Equation 10.

The constant of proportionality C can be calculated quite readily from well-known force-deflection formulas.[3] As a simple example, for the case of a sphere contacting a similar material flat plate,

$$y = 1.55\left(\frac{P^2}{E^2\,D}\right)^{1/3}$$

Hence,

$$P = 0.518\,E\,y^{3/2}\sqrt{D}$$

Therefore, from a comparison with Equation 8,

$$C = 0.518\,E\sqrt{D} \qquad (11)$$

for the case of a sphere contacting a flat plate of similar material.

LINEAR - DEFORMATION MEMBER PLUS CURVED SURFACE: Occasionally, a linear-deformation member is combined with a curved surface contact region. Such is the case for localized stress control on the end of a clutch pawl, as is illustrated in Example 3. For such a situation, a very close approximation may be made within the tolerable range for P. The contact force P can be related to the total deformation y by the following approximation:

$$P = Cy^a \qquad (12)$$

In Equation 12, C is again a constant of proportionality and a is a number which generally lies between unity and 3/2.

For such a combination of linear and general surface contact deformations, the exponent a can be calculated quite readily. For various values of contact force P, the total deformations y can be calculated by standard procedures, that is, by summation of individual deformations. Contact force P vs. total deformation y can then be plotted on log-log graph paper. A straight line will generally fall very close to all points, providing P is limited to tolerable values dictated by the contact stress. The slope of the straight line is the value for the exponent a.

After a is determined from the plot, the value of C is obtained by direct substitution in Equation 12. This general method for calculating both C and a for Equation 12 is illustrated in Example 3.

The likely range for maximum contact force P_{max} can be calculated in a similar manner to the derivations of Equations 9 and 10 for the general surface contact case.

Hence, from the finite-mass assumption of Equation 2, and by use of Equations 4 and 12, the following expression is obtained:

$$P_{max} = C^{1/(a+1)}\left\{ \frac{(a+1)}{2}\left[(M\,V_i^2 + m\,v_i^2) - (M + m)\,U_c^2 \right] \right\}^{a/(a+1)} \qquad (13)$$

In Equation 13, P_{max} is the maximum contact force as obtained by the finite-mass assumption for the force-deflection relationship defined by Equation 12. In Equation 13, U_c is obtained as before by direct substitution in Equation 1.

In a like manner, from Equations 3, 4, and 12,

$$P_{max} = C^{1/(a+1)}\left\{ \frac{(a+1)}{2}\,m\,(V_i - v_i)^2 \right\}^{a/(a+1)} \qquad (14)$$

In Equation 14, P_{max} is the maximum contact force as obtained by the infinite-mass assumption for the force-deflection relationship, Equation 12.

Equations 13 and 14 define the likely range wherein the maximum contact force P_{max} will fall. The finite-mass maximum contact force from Equation 13 will always be less than the infinite-mass maximum contact force from Equation 14.

A Mechanisms Conference Paper

This article was presented as a paper at the Fourth Conference on Mechanisms, Purdue University, October 14-15, 1957. These Conferences are cosponsored by the Purdue School of Mechanical Engineering and *Machine Design*.

REFERENCES

1. S. Timoshenko and J. N. Goodier—*Theory of Elasticity*, McGraw-Hill Book Co., New York, 1951, pp. 383 and 438-459.
2. B. F. Langer—"High Impact Shock," MACHINE DESIGN, Aug., 1955, pp. 193-197.
3. Raymond J. Roark—*Formulas for Stress and Strain*, McGraw-Hill Book Co., New York, 1939, Case 1, p. 287.
4. Reference 3, pp. 287-290.
5. Reference 3, p. 331.

Formulas for simplifying

Planet-Pinion Spacing

in planetary and differential-gear systems

By F. A. SHEN
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Department of Mechanical Engineering
Illinois Institute of Technology
Chicago, Ill.

PLANETARY or differential gear systems are usually designed with two or more planet pinions incorporated to balance the gear-tooth load and increase the capacity of the gear system. An accompanying requirement is that the centrifugal load induced by the pinion mechanism must be taken into account.

Proper spacing of the planet pinions is essential, and there are four ways in which this can be achieved:

1. Space the planet pinions equally around the sun gear if this arrangement is permitted by the number of teeth in the related gears and pinions.

2. For an even number of planet pinions, place each pair diagonally opposite each other. When there is more than one pair, space as equally as possible between pairs.

3. Space the planet pinions in such a position that the forces caused by the centrifugal and tooth loads form a closed polygon.

4. For a planetary-gear system having constant speed and constant torque, space the planetary pinions as equally as possible and balance the system dynamically, provided the amount of balanc-

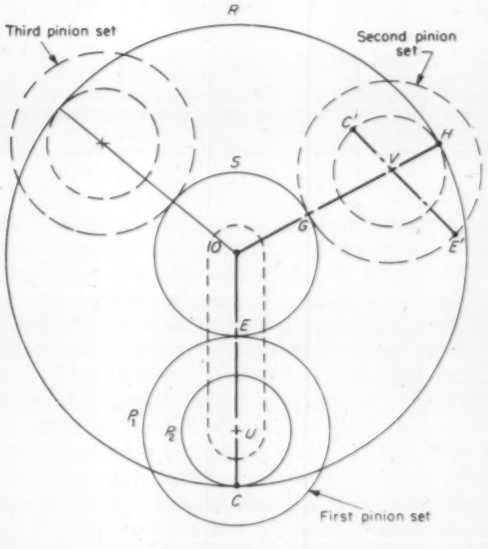


Fig. 1—Planet pinions equally spaced in compound planetary gear system

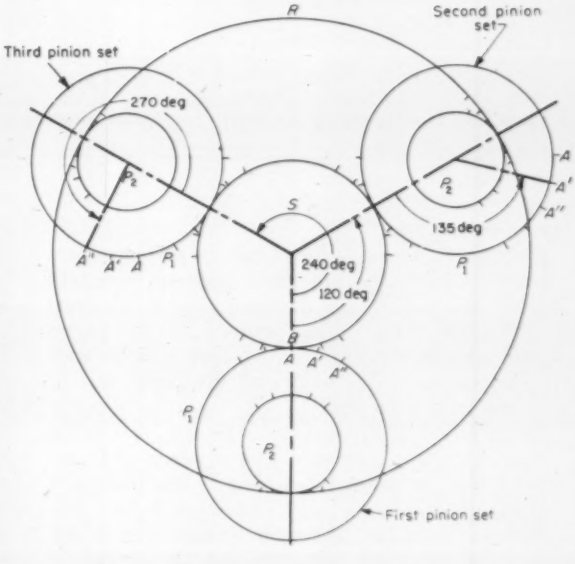
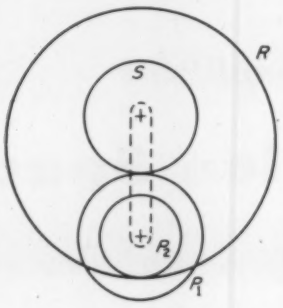


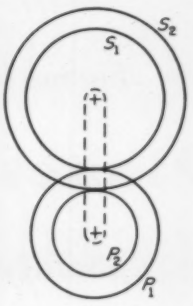
Fig. 2—Tooth-phase offset allows planet pinions to mesh properly

These cases present solutions for equal spacing of planet-pinion sets in arrangements most commonly employed. In the analysis of any gear arrangement not shown, the appropriate spacing equation can be derived in a manner similar to that by which Equation 2 has been developed.



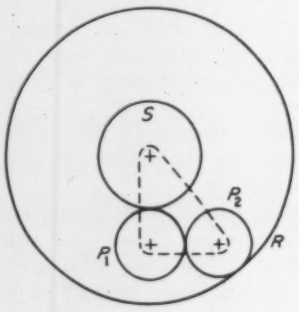
$$\frac{N_R + N_S \dfrac{N_{P2}}{N_{P1}}}{K} + J\frac{N_{P2}}{N_{P1}} = \text{Whole number}$$

Case 1—Sun and ring gears in mesh with compound pinions



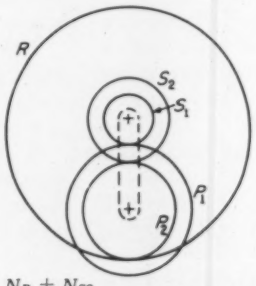
$$\frac{N_{S2} - N_{S1} \dfrac{N_{P2}}{N_{P1}}}{K} + J\frac{N_{P2}}{N_{P1}} = \text{Whole number}$$

Case 2—Two sun gears in mesh with compound pinions



$$\frac{N_R - N_S}{K} = \text{Whole number}$$

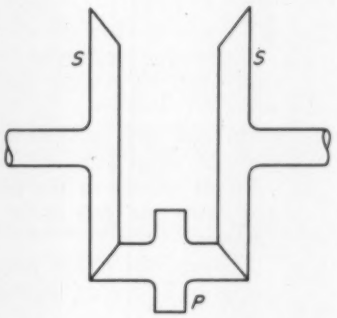
Case 6—Sun and ring gears in mesh with two meshing simple pinions



$$\frac{N_R + N_{S2}}{K} = \text{Whole number}$$

$$\frac{N_{S2} - N_{S1} \dfrac{N_{P2}}{N_{P1}}}{K} + J\frac{N_{P2}}{N_{P1}} = \text{Whole number}$$

Case 7—Two sun gears and ring gear in mesh with compound pinions. Number of teeth must satisfy both equations simultaneously



$$\frac{2N_S}{K} = \text{Whole number}$$

Case 8—Two equal bevel sun gears in mesh with simple bevel pinions

ing is not excessive.

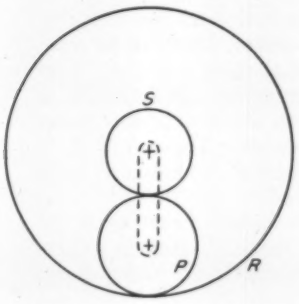
Methods 2, 3, and 4 for planetary placement are applicable when the specific conditions necessary for each are present, and the results can be obtained by trial and error. Equal spacing of the planet pinions around the sun gear, Method 1, is the preferred procedure. The following discussion will be confined to this method.

Besides developing a general approach, this article illustrates typical planetary arrangements and presents specific formulas for spacing of the pinions.

General Formula: The most general type of system is the compound planetary-gear set. A general formula, which will be developed for it, simplifies the problem of equally spacing the pinions. Certain rules regarding the number of teeth in related gears must be respected in this development. This general formulation is advantageous because, with modification, it can be made applicable to various types and arrangements of planetary elements.

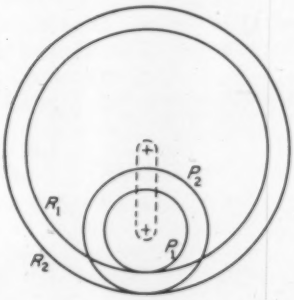
In the compound planetary-gear system shown in Fig. 1, the tangent circles represent the pitch circles of gears and pinions. This system contains pinion P_1 in mesh with sun gear S, and pinion P_2 in mesh with ring or internal gear R. P_1 and P_2 rotate as one unit, and all planet pinions in the same system usually have the same fixed tooth phase.

Treating this as an ideal example, allow P_1 and S to mesh at E, and P_2 and R to mesh at C. S and R are assumed to be fixed, and the solid lines of P_1 and P_2 indicate the first set of compound planet pinions. Remove the planet pinion from mesh and, while also rotating it, move it to the



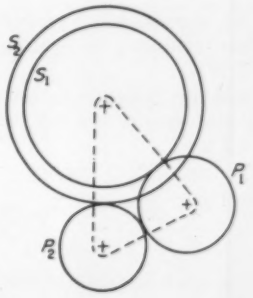
$$\frac{N_R + N_S}{K} = \text{Whole number}$$

Case 3—Sun and ring gears in mesh with simple pinions



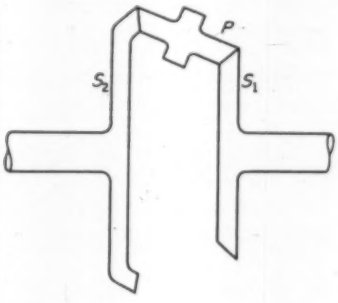
$$\frac{N_{R1} - N_{R2}\dfrac{N_{P1}}{N_{P2}}}{K} + J\frac{N_{P1}}{N_{P2}} = \text{Whole number}$$

Case 4—Two ring gears in mesh with compound pinions



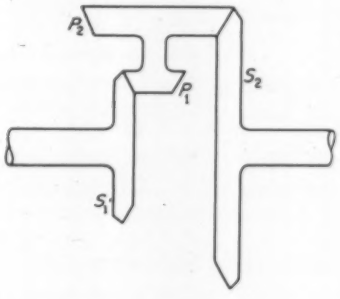
$$\frac{N_{S1} + N_{S2}}{K} = \text{Whole number}$$

Case 5—Two sun gears in mesh with two meshing simple pinions



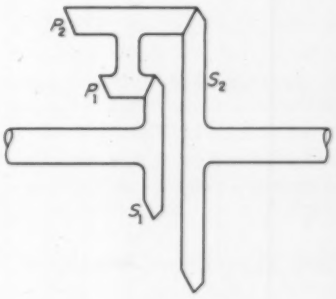
$$\frac{N_{S1} + N_{S2}}{K} = \text{Whole Number}$$

Case 9—Two bevel sun gears of different pitch diameters in mesh with simple bevel pinions



$$\frac{N_{S2} + N_{S1}\dfrac{N_{P2}}{N_{P1}}}{K} + J\frac{N_{P2}}{N_{P1}} = \text{Whole number}$$

Case 10—Two bevel sun gears of different pitch diameters in mesh with compound bevel pinions



$$\frac{N_{S2} - N_{S1}\dfrac{N_{P2}}{N_{P1}}}{K} + J\frac{N_{P2}}{N_{P1}} = \pm \text{Whole number}$$

Case 11—Two bevel sun gears of different pitch diameter meshing on same side of compound bevel pinions

new position shown by dotted lines, such that $UOV = E'VG\,(N_{P1}/N_S) = 360$ deg/K; K is the number of equally spaced planet-pinion sets required and E' is the new position of point E. Remesh P_1 and S at G. In order for P_2 and R to mesh again at H, the sum of the number of teeth on arcs CH and HC' has to be a whole number. That is, relative displacement at the pitch circles of the two gears must contain a whole number of teeth or the gears will not mesh. It then follows that

$$\frac{\text{Length of arc } CH}{\text{Circular pitch of } R} = \frac{N_R}{K}$$

and

$$\frac{\text{Length of arc } HC'}{\text{Circular pitch of } P_2} = \frac{N_S}{K}\,\frac{N_{P2}}{N_{P1}}$$

where N = number of teeth and subscripts denote appropriate gears. Therefore,

$$\frac{N_R}{K} + \frac{N_S}{K}\,\frac{N_{P2}}{N_{P1}} = \frac{N_R + N_S\dfrac{N_{P2}}{N_{P1}}}{K} = \text{Whole number} \qquad \ldots\ldots(1)$$

The foregoing development is for an ideal case. If P_2 and R do not engage at this position, a shift of the planet pinion by some multiple of the P_1 tooth angle may rectify the mesh. Thus Equation 1 can be modified into a more general form:

$$\frac{N_R + N_S\dfrac{N_{P2}}{N_{P1}}}{K} + J\frac{N_{P2}}{N_{P1}} = \text{Whole number} \qquad (2)$$

where J is a whole number from 1 to $(N_{P1}/Q) - 1$ representing the tooth-phase shift of the planet

pinion for successive planet-pinion sets, and Q is the highest, common, integral factor, if any, between N_{P1} and N_{P2}.

It would be possible to interchange pinion P_1, with P_2 and gear S with R, which would change Equation 2 to

$$\frac{N_S + N_R \dfrac{N_{P1}}{N_{P2}}}{K} + J' \frac{N_{P1}}{N_{P2}} = \text{Whole number}$$

where J' is a whole number from 1 to $(N_{P2}/Q) - 1$ representing the tooth-phase shift of the planet pinion.

Example: The compound planetary-gear system in Fig. 2 illustrates the application of Equation 2. Let $N_S = 27$, $N_R = 67$, $N_{P1} = 24$, $N_{P2} = 16$, $K = 3$ and $Q = 8$ (that is, for $N_{P1} = 24$ and $N_{P2} = 16$, 8 is the highest, common, integral factor). Then, substituting the appropriate values in Equation 2 gives

$$\frac{67 + 27 \dfrac{16}{24}}{3} + J \frac{16}{24} = 28\ 1/3 + J\ 2/3$$

Next, determination of the upper limit of J yields $(24/8) - 1 = 2$. Thus J has upper and lower limits of 2 and 1. Testing these limits shows that $J = 2$ produces 29 2/3, $J = 1$ produces 29. Thus the required whole number is obtained only when $J = 1$.

Tooth Phase Offset: Results of the example indicate that the three planet pinion sets can be equally spaced around the sun gear. The second planet pinion set must merely be placed at one tooth-phase offset with reference to the first pinion set. The third pinion set must be offset one tooth-phase from the second (or two from the first).

The effect of this tooth-phase offset can be more fully explained. Assume that there is a tooth A on P_1, Fig. 2, which has a centerline corresponding to the centerline of a tooth on P_2, and all the planet pinions of each set are identical. Tooth A of P_1 in the first planet set is inserted in sun-gear tooth space B and P_2 meshes with R.

If tooth A of P_1 in the second planet set is inserted in sun-gear tooth space B, and the pinion is moved 120 deg counterclockwise while being rotated $120N_S/N_{P1}$ deg, gears P_2 and R will not mesh. However, if A', the first tooth clockwise of A on P_1, is inserted in space B and the movement of the pinion is repeated, A' will be in the position shown, and P_2 and R will mesh. In the same manner, P_2 of the third planet-pinion set can be made to mesh with R if A'', the second tooth clockwise of A on P_1, is inserted in tooth space B, and the pinion is then moved 240 deg and rotated 240 N_S/N_{P1} deg counterclockwise to the required position as shown.

The tooth phase relationship between P_1 and P_2 could be altered for each planet pinion in the system to provide the required equal spacing. This would complicate the manufacturing procedure because each individual planet pinion would have to have tooth-phase relation accurately located. If the planetary-gear system is designed with all of the planetary pinions having the same tooth-phase relationship, the manufacturing process is simplified, and equal spacing is obtained by proper rotation of each planet pinion.

It is necessary, however, to treat each type of planetary-gear system separately and to derive the appropriate formula for the system being treated. The accompanying cases, with formulas for spacing of the pinions, serve as examples and design aids.

Tips and Techniques

Teflon Tape

When the anodizing wears off of aluminum drafting machine scales, the base metal tends to smudge and mark the drawing. This can be prevented by attaching a strip of self-adhesive cementable Teflon tape to the bottom of the scales. An added benefit is the ease with which the drafting machine moves about the board because of less friction.

Another use of cementable Teflon tape is to cover all surfaces over which the sealing sleeve of a dry developing whiteprinter is to slide. This has no adverse effect on the sealing of the sleeve, and the slipperiness of Teflon extends the life of the sleeve because of less wear. The sleeve doesn't stick when machine is started in the morning.—Henry W. Brandt Jr., *Des Moines, Iowa.*

Subtracting on Slide Rule

Slide rule computations occasionally require a subtraction process. This can be accomplished directly on the slide rule by using the following general formula:

$$a - b = \left(\frac{a}{b} - 1 \right) b$$

Given the two numbers a and b, with $a > b$, set b on the C scale opposite a on the D scale. The quotient appears under the index. Move the index to a value of one less than the quotient, and the difference is read on the D scale under b on the C scale.—Ray C. Hawkins, *Napco Industries Inc., Minneapolis, Minn.*

DESIGN ABSTRACTS

mechanical

Mechanical Memory Devices

Arthur Mirel, American Machine & Foundry Co.

Beginning with "standard" components of memory devices, such as the cam, the author explains the principles of complex multielement electromechanical and electrohydraulic concepts.

ASME paper 58-MD-1, from 1958 Design Engineering Conference, Chicago; 5 pp.

Problems in Automatic Machinery

Maurice J. Faltot, New Jersey Machine Corp.

An analytic approach to problems encountered in straight line, rotary, and a combination of straight-line and rotary automatic machines. Conveyor systems, index mechanisms, orientation mechanisms, pressure mechanisms, and intermittent-motion mechanisms are covered fully.

ASME paper 58-MD-7, from 1958 Design Engineering Conference, Chicago; 9 pp.

Automatic Inspection Devices

David H. McConnell, The Sheffield Corp.

New "in-process" or "post-process" gaging systems enable machine-tool manufacturers to build precision into modern tools that produce fine tolerances at high production rates. In-process gages measure the workpiece as it is being shaped and control tool application directly. Post-process gages inspect the workpiece after it is machined and correct or stop the process from turning out faulty parts. Pneumatic gages used in these systems are described.

ASME paper 58-MD-2, from 1958 Design Engineering Conference, Chicago; 5 pp.

What is a Digital Computer?

Donald E. Hart, General Motors Corp.

Remarkable speed of new computers enables engineers to produce designs rapidly by calculation instead of by expensive and noncomprehensive methods. Computer functions and adaptability of computers to engineering work are covered. A typical problem is formulated, analyzed, programmed, and coded for computer solution.

General Motors Engineering Journal, *April-May-June, 1958, page 2.*

materials

High-Strength Structural Sandwich Construction

William E. Dirkes, Wright Air Development Center

Detailed materials, strength properties, design criteria, fabrication, and repair techniques are available in the publications referenced. This paper presents a general review of sandwich construction to illustrate what it is, types of configurations most widely used, and a brief discussion of some critical fabrication and design problems.

ASME paper 58-MD-10, from 1958 Design Engineering Conference, Chicago; 8 pp.

Compatibility of Metals in Bearing Contact

C. L. Goodzeit, General Motors Research Center

Antiseizure properties, resistance to fatigue from dynamic loads, corrosion resistance, and toleration of dirt in lubricant, are basic considerations in selecting journal-bearing metals. These and other factors, such as operating temperatures, manufacturing techniques, and design are discussed.

ASME paper 58-MD-9, from 1958 Design Engineering Conference, Chicago; 11 pp.

Effect of Rate on Tensile Properties of Plastics

G. R. Rugger, E. McAbee, and M. Chmura, Picatinny Arsenal

Information obtained by the Army Ordnance Corps' Plastics Laboratory at Picatinny Arsenal on the gathering of high-rate data by the actual performance of tests upon some typical plastic materials in the 5-15 milliseconds to fracture range.

ASME paper 58-MD-3, from 1958 Design Engineering Conference, Chicago; 3 pp.

A Method for Soldering Aluminum

G. M. Bouton and P. R. White, Bell Telephone Laboratories Inc.

Ordinary methods for affixing two pieces of aluminum have presented a number of difficulties—a major one being formation of aluminum oxide. A new soldering technique is described in which zinc-base solders cause the oxide to loosen. Techniques for wetting the alumi-

num and tensile test results on T-joints are discussed. Various construction configurations showing typical joining methods are evaluated for efficient soldering.

Bell Laboratories Record, *May*, 1958, *page* 157.

Engineering Applications Of Radioisotopes

Farno L. Green, General Motors Corp.

A brief account of the research to date which is aimed at applying nuclear techniques to research, development, and production problems. It is estimated that approximately 90 per cent of the man-hours spent on application of radioisotopes involve solving mechanical engineering problems related to shielding and remote handling.

General Motors Engineering Journal, *"Studies of Radioisotopes Show Promise for Present and Future Applications in Engineering," April-May-June*, 1958, *page* 18.

Plastics Creation and Evaluation

Development of a new nylon by Stanford Research Institute plastics laboratory. This nylon can be used as a high-level radiation dosimeter because it undergoes an unusual color change in proportion to the dose of gamma radiation received. Included are descriptions of the basic polyamides which make up this nylon, and some application possibilities. Basic structure and some physical properties are discussed.

SRI Journal, *Vol. 2, No. 1*, 1958, *page* 24.

Organic Vapor and Relay Contacts

L. H. Germer and J. L. Smith, Bell Telephone Laboratories Inc.

Relay contacts in service sometimes erode much faster than laboratory life tests indicate they should. Often such erosion is due to "activation"—a subtle effect of organic vapors present in the operating environment. Activation has been studied for some years and the phenomenon, now quite well understood, is analyzed here.

Bell Laboratories Record, *April*, 1958, *page* 124.

Lubricant Considerations in Centralized Systems

Richard D. Skoglund and Robert K. Gould, Texaco Research Center

Selection of suitable lubricants for central systems involves consideration of several factors. A discussion of these factors with particular emphasis on grease pumpability characteristics is presented. Laboratory data are shown for various bench tests that have been used to obtain predicted performance results for greases in centralized lubrication systems.

ASME paper 58-MD-8, from 1958 Design Engineering Conference, Chicago; 9 pp.

hydraulic

Electro-Hydraulic Applications To Machine Tools

A. H. Dall and E. J. Rivoira, Cincinnati Milling Machine Co.

Popularity of electrohydraulic drive systems for machine tools is discussed from the analysis of needs of the system as size, speed, and accuracy are changed. Specially developed components are discussed in terms of requirements of proportional machine-tool servosystems, and contributions of these components are presented in transfer functions representative of an electrohydraulic servosystem.

ASME paper 58-MD-5, from 1958 Design Engineering Conference, Chicago; 8 pp.

Systems For Airborne and Ground Applications

F. L. Moncher and L. D. Taylor, Vickers, Inc.

Increased performance requirements of high-speed aircraft and missiles have put mounting responsibility on system designers. A description of basic control systems and typical applications are presented in this paper along with a review of hydraulic-design considerations which show how to use these systems to best advantage.

ASME paper 58-MD-6, "Current Design Practices in Electro-Hydraulic Control Systems for Airborne and Ground Applications," from 1958 Design Engineering Conference, Chicago; 15 pp.

electrical

Magnetic Amplifiers: Principles and Applications

L. W. Stammerjohn, Bell Telephone Laboratories Inc.

First of a series of three articles dealing with basic principles of magnetic amplifier operation and basic circuits from which more complicated amplifiers are built. Also included are inherent capabilities and limitations which govern application.

Bell Laboratories Record, *January*, 1958, *page* 16.

Electrical Design in Servo Systems

Walter L. McCann, Giddings and Lewis Machine Tool Co.

An application of servo response to machine tools, achieving automatic control and increased accuracy to meet the demands of high-performance requirements.

ASME paper 58-MD-11, from 1958 Design Engineering Conference, Chicago; 8 pp.

Electrical Contact with Thermo-Compression Bonds

H. Christensen, Bell Telephone Laboratories Inc.

A major difficulty in development of high-frequency transistors has been the formation of reliable electrical contacts between extremely fine wires and minute areas of semiconductor crystals. A promising solution to this problem—a technique known as thermo-compression bonding—is discussed and evaluated.

Bell Laboratories Record, *April*, 1958, *page* 127.

Printed Circuits

N. Osifchin and S. J. Stockfleth, Bell Telephone Laboratories Inc.

Development work done at the Laboratories in fundamental studies on raw materials, and physical and electrical characteristics of printed wiring are covered. Printed circuit technique and space requirements are also analyzed.

Bell Laboratories Record, *April*, 1958, *page* 117.

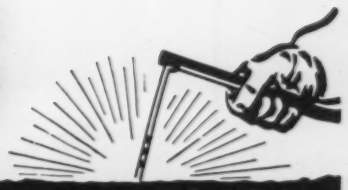
ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; papers 25 cents to members, 50 cents to nonmembers.

SRI Journal—Stanford Research Institute, Menlo Park, Calif.

Bell Laboratories Record—Bell Telephone Laboratories Inc., 463 West St., New York 14, N. Y.

General Motors Engineering Journal—GM Technical Center, Box 177, North End Station, Detroit 2, Mich.

Weldynamics



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Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Rubber Hydraulic Packings

Included in folder on cup-type fabricated rubber hydraulic packings are application notes, table of maximum clearances, and list of cup sizes. 4 pages. E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa. C

Circle 621 on Page 19

Gear Couplings

Brief description and specifications are given in Bulletin 56 on standard gear and flexible couplings, a nylon gear coupling, and cut-out couplings. 4 pages. John Waldron Corp., New Brunswick, N. J. D

Circle 622 on Page 19

Temperature Controls

General purpose, dual switch, explosion-proof, and indicating type temperature controls, in both local mounted and remote bulb types, are covered by descriptive data and specifications in Condensed Catalog 400. Information allows immediate ordering of over 160 models. 8 pages. United Electric Controls Co., 79 School St., Watertown 72, Mass. B

Circle 623 on Page 19

Hydraulic Cylinders

Series C4H hydraulic cylinder rated 2000-3000 psi affords 14 standard mountings and four rod end styles. Bore sizes range from 1⅛ to 12 in. Bulletin 658 provides data. 6 pages. Sheffer Corp., 326 W. Wyoming Ave., Cincinnati 15, Ohio. G

Circle 624 on Page 19

Ductile Iron

"A Case for Ductile Iron Economy" is title of Bulletin 1102 which shows progressively how patterns and molds are made, how foundry charges and pours metal, and how castings are machined and finished. Casting weight ranges from few ounces to many tons. 12 pages. T. B. Wood's Sons Co., Chambersburg, Pa. E

Circle 625 on Page 19

Air Valves

Dimensions and specifications on the 2-in. electropneumatic poppet valve are provided on Data Sheet F-8585. Minimum operating pressure is 10 psi. Barber-Colman Co., Aircraft Controls Div., Rockford, Ill. K

Circle 626 on Page 19

Shading Films & Symbols

Brochure on Contak shading films illustrates 72 basic films in black ink, for shading white areas, and in white ink, to break up black areas. Symbols for geological map-making and other graphic applications are also shown. 6 pages. Chart-Pak, Inc., Transograph Div., Leeds, Mass. B

Circle 627 on Page 19

Technical Plastics

Complete information, including properties, characteristics, and Government specifications relative to Synthane plastics in sheet, rod, tube, and fabricated part forms, is presented in Form S-358-75. Machines and processes used to fabricate laminates are shown. 28 pages. Synthane Corp., Oaks, Pa. E

Circle 628 on Page 19

Air Cleaners & Controls

Separators, afterdriers, filters, line drains, sump and tank drains, air governors, pressure regulators, and lubricators are but a few of the hundreds of air line devices cataloged in Bulletin 157 on Airomatic air products. Operating and performance data are included. 24 pages. Wilkerson Corp., 1601 W. Girard Ave., Englewood 8, Colo. K

Circle 629 on Page 19

Silicone Products

Major silicone products and their many uses are discussed in Bulletin CDS-129. Data cover rubber, fluids, resins, water repellents, electrical insulation, release agents, lubricants, paint vehicles, and anti-foam agents. 8 pages. General Electric Co., Silicone Products Dept., Waterford, N. Y. D

Circle 630 on Page 19

Diode Function Generator

Model 100 diode function generator which features a punched card memory that allows preprogramming is subject of bulletin. Generator is designed for analog computer facilities. 2 pages. Electrol, Inc., Box 1152, Beverly Hills, Calif. L

Circle 631 on Page 19

Mercury Switches

Hypressure hydrogen arc-quenched mercury switches are described as to electrical ratings, operating angles, and physical dimensions in Bulletin D-49. Mercury-to-mercury and mercury-to-metal units are shown. 6 pages. Durakool, Inc., Elkhart, Ind. J

Circle 632 on Page 19

Casting Copper Alloys

Company's method of pressure die casting, permanent mold casting, and semi-permanent mold casting of copper base alloys is discussed in booklet. A variety of typical castings is shown and design, size, tolerance, alloy and general information is given. Physical and mechanical properties are tabulated. 28 pages. Pressco Casting & Mfg. Corp., Chesterton, Ind. J

Circle 633 on Page 19

Bearing Material

Bulletin DU-458 presents information on DU self-lubricated bearing material and describes its advantages in typical and unusual bearing uses. Material has compressive strength of up to 23 tons per sq in. and operating range from −328 to 536° F. 8 pages. United States Gasket Co., Camden 1, N. J. E

Circle 634 on Page 19

Mercury Plunger Relays

Literature on Adlake mercury plunger relays comprises a small booklet which gives catalog numbers, ratings, UL classifications and other data, and a folder which pictures four popular models and illustrates how the relay works. 12 and 4 pages, respectively. Adams & Westlake Co., Elkhart, Ind. J

Circle 635 on Page 19

Environmental Instruments

Guide W1831 outlines company indicating, recording, programming, and controlling instruments for environmental test equipment. It also specifies the most widely used temperature-measuring systems; absolute pressure gages; pneumatic, electric, and electronic controllers; and program controllers. Bristol Co., Waterbury 20, Conn. B

Circle 636 on Page 19

Wood Products

"Solving Problems in Wood" is title of brochure which reviews the development of this company, describes research and devolpment, pictures plant facilities, and shows a host of wood products from the smallest turning to huge exterior laminates. 28 pages. Gamble Brothers Inc., 4601 Allmond Ave., Louisville 9, Ky. G

Circle 637 on Page 19

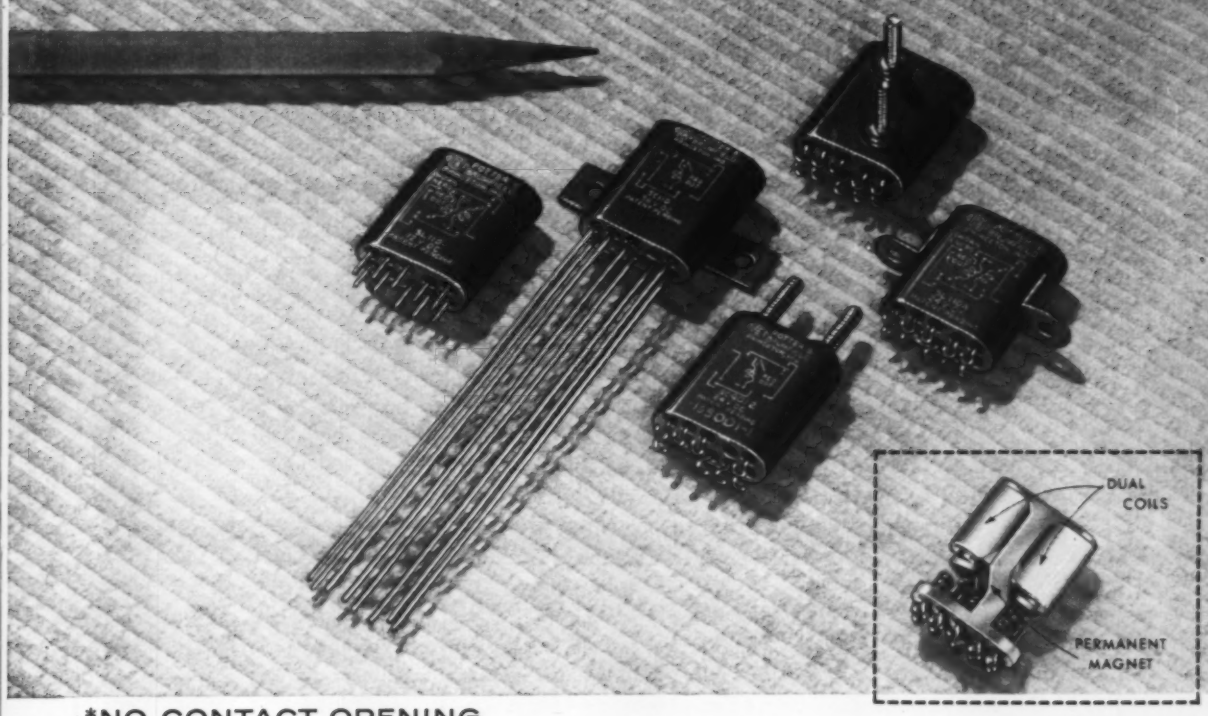
Reproduction Process

Described in bulletin "The Bruning Copyflex Process" are the various types of prints that can be made with this diazotype reproduction method. Direct-copy prints include black line or color line on white or tinted stock, multicolor films for projection or overlay, translucent duplicate originals, dimensionally stable film and glass cloth prints, and re-

P&B MICRO-MINIATURE RELAYS LEAD IN

performance

SHOCK: 100g* VIBRATION: 30g to 2000 cps*

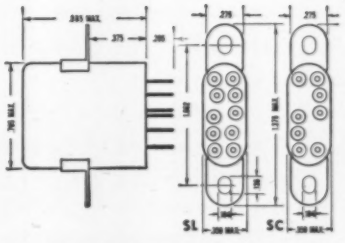


*NO CONTACT OPENING

New P&B crystal-case size relays, the SC and the SL (magnetic latching), show amazing shock and vibration capabilities. They absorb shocks of 100g and vibrations 30g to 2000 cps. without contact openings!

A highly efficient magnetic structure utilizing a permanent magnet makes possible at least twice the contact pressure found in DPDT relays of comparable size. One watt of power for three milliseconds operates either relay. Transfer time is unusually fast —0.5 milliseconds maximum.

For more information, contact your P&B sales engineer, or write Potter & Brumfield, Princeton, Indiana.



SL—dual coil latching relay. Operates on a 1 watt, 3 ms. pulse at nominal voltage. Permanent magnet latch locks the armature in either position.

SC—non-latching relay with series-connected dual coils. Operates on approximately 1 watt at nominal voltage. Coils must remain energized to hold the armature in the operate position.

SC and SL Series Engineering Data

GENERAL:
Insulation Resistance: 10,000 megohms, min.
Breakdown Voltage: 1,000 V. RMS.
Shock: 100g.
Vibration: 30g 55 to 2000 cps.; 0.195" max. excursions from 10-55 cps.
Temperature Range: —65° C. to + 125° C.
Weight: 15 grams without mounting bracket.
Operate Time: 3 MS. max. with 550 ohm coil @ 24 V. DC. (SL: 630 ohm coil at 24 V. DC).
Transfer Time: 0.5 MS max.
Terminals: (1) Plug-in for microminiature receptacle of printed circuit board.
(2) Hook end solder for 2 #24 AWG wires.
(3) 3" flexible leads.
Enclosure: Hermetically sealed.

CONTACTS:
Arrangement: 2 Form C.
Material: Gold flashed palladium.
Load: 2 amps @ 28 V. DC, resistive; 1 amp @ 115 V. 60 cycles AC, resistive.
Pressure: SC—16 grams min.; SL—20 grams min.

COIL:
Power: Approx. 1.0 watt at Nominal Voltage.
Resistance: SL—40 to 1400 ohms; SC—35 to 1250 ohms.
Duty: Continuous.

MOUNTINGS:
Bracket, stud and plug-in.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD INC.

PRINCETON, INDIANA • SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY

Circle 482 on Page 19

if **BRAKES** are your problem

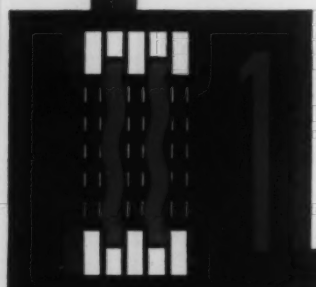
let's talk

Maxitorq

the floating disc clutch that is equally efficient as a **BRAKE**

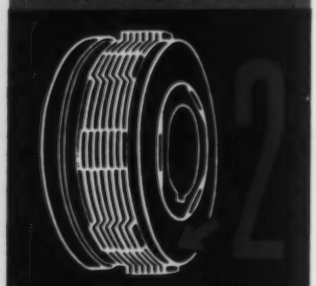
Single

Double



1

Unique separator springs completely separate floating discs when in neutral, preventing drag or heating.



2

Locking plates hold discs and separator springs in correct and complete assembly. Easily installed, easily serviced.

3

Simple manual adjustment by rotating side locked ring. Requires no special tools.

Here is a practical and efficient answer to the majority of brake problems in machine tool and industrial machinery drives, because the service-proved advantages of MAXITORQ Floating Disc design apply equally to the use of these dependable units *either as clutches or brakes.*

These advantages include compact, simple and rugged construction, ideally suited to "designed-in" applications. With patented MAXITORQ separator spring design, engagement and disengagement is always positive and complete, with no drag or heating in neutral. MAXITORQ Brake or Clutch Units are furnished complete, ready to install, with simple manual adjustment—no special tools required.
Can be used either WET or DRY and assure long, trouble-free service. Let our Engineering Department help you solve either BRAKE or CLUTCH problems this proved way.
Send us an outline of your needs. Write Dept. MD-6.

The Carlyle Johnson Machine Co.

MANCHESTER • CONNECTICUT

Let's talk MAXITORQ

3CJM

flex prints on translucent film. 12 pages. Charles Bruning Co., 1804 W. Central Rd., Mount Prospect, Ill. J

Circle 638 on Page 19

Rubber & Vinyl Parts

Company facilities for component "Customeering" of molded rubber parts, rubber-to-metal parts, hard rubber goods, rubber mats, extruded goods, rollers, ventilating hose, and rubber tires are described in Form 715. 6 pages. Ohio Rubber Co., Willoughby 1, Ohio. F

Circle 639 on Page 19

Magnetic Equipment

Catalog PR-19 on permanent magnets, magnetizers, and demagnetizers lists over 70 cast Alnico V magnets and over 30 sintered Alnico II magnets available in experimental quantities. Magnets are used in aircraft, guided missiles electronic products, automation, and instrumentation devices. 12 pages. Indiana Steel Products Co., Valparaiso, Ind. J

Circle 640 on Page 19

Investment Casting

Condensed data file contains charts showing comparative tolerances, sections, finishes, tooling time, and relative costs of all casting processes. Parts simplification is discussed and available metallurgical services are outlined. Rode, Inc., 3 Green St., Woburn, Mass. B

Circle 641 on Page 19

Couplings

Fixed bore flexible, bushed type flexible, sleeve, rigid, jaw type, and chain couplings are cataloged with specifications, price data, and service rating information in Form C-210-A. The new jaw couplings with malleable construction are designed for split taper compression bushings. 12 pages. Browning Mfg. Co., Maysville, Ky. G

Circle 642 on Page 19

Hydraulic Cylinders

Comprehensive information provided in Bulletin JH-104N on hydraulic cylinders rated up to 3000-5000 psi covers construction, maximum usable pressures, selection factors, cylinder and rod dimensions, aids for preventing excessive bearing wear, and engineering notes. 32 pages. Flick-Reedy Corp., Miller Fluid Power Div., 2040 N. Hawthorne Ave., Melrose Park, Ill. J

Circle 643 on Page 19

Ductile Iron Castings

Data on application of ductile iron for machine parts is provided in Bulletin MPC. Booklet gives the product designer material specification, and shows facilities available for producing casting to meet specific job requirements. 12 pages. Cooper-Bessemer Corp., Mount Vernon, Ohio. G

Circle 644 on Page 19

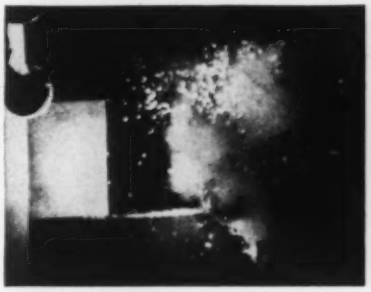
Multiple Extrusion

What multiple extrusion means to upholstery, conveyor, and electrical manu-

How to get easy answers to hard questions like these

1. Why excess wear in a ratchet feed?

2. How much spark to light a lighter?



3. How to control a food-puffing gun?

4. Why did gear teeth mesh erratically?

These questions have a common element: They all involve action that's too fast for the eye to see. Your first big step to getting the answers is to be able to see what's going on. With high speed movies you can slow down mechanical action (or fluid flow) enough to study it, take steps to make adjustments. The high speed movies above showed, for example:

1. How a bouncing pawl caused excess wear in a ratchet feed.
2. Where to place a spark wheel to get the best lighting action.
3. What exact timing must be maintained to work a food-puffing gun.
4. How torsion in a vertical shaft caused improper gear meshing.

Kodak's new High Speed Movie Film gives wide range to any industrial high speed camera. You can choose from eight different types of films that include black-and-white, full color, and black-and-white by infrared radiation.

Loading these versatile films into a Kodak High Speed Camera is a smart choice, too. It's simple to operate and requires no extensive photographic experience for successful use. And it gives all the speed you need for most industrial applications.

For details on how Kodak's High Speed Camera and Films might be used to help solve your product design or performance problems, send today for the illustrated booklet "High Speed Motion Pictures at the Service of the Engineer."

EASTMAN KODAK COMPANY, Rochester 4, N. Y.

the Kodak *HIGH SPEED* Camera

Kodak
TRADE MARK

Circle 484 on Page 19

SMARTEST MAN ON WHEELS

Call on the quickest, most experienced sales engineering service in the wheel industry today.

In short, call ELECTRIC. Get quick answers from a man who knows your product and his product. Who can quote production schedules and prices—while you're planning.

Get the follow-through, too, that ELECTRIC is famous for. Get the production capacity and quality that an automated operation, an ideal location and years of agricultural and industrial experience promise you.

Call or write today for the exact disc or spoke-type wheel (steel or rubber-tired), rim, hub, axle or component part you're looking for.

"What we sell is service"

ELECTRIC WHEEL CO.

1120 N. 28th St., Quincy, Illinois
BAldwin 2-5320

DIVISION OF THE FIRESTONE TIRE & RUBBER COMPANY

Circle 485 on Page 19

facturers is briefly illustrated in folder entitled "How Can You Use This?" 6 pages. Multiple Extrusions, Inc., Winona, Minn. K

Circle 645 on Page 19

Flexible Couplings

Gear-Grip and Dyna-Line flexible couplings for subfractional and fractional horsepower transmission applications are covered descriptively in Catalog C-111. Units are made for 1/12 to 30-hp requirements. 4 pages. Guardian Products Corp., Coupling Div., Michigan City, Ind. J

Circle 646 on Page 19

Molded Plastics

Automotive, electrical, appliance, and industrial molded plastics are pictured in brochure which discusses which plastic to use, good plastics design, and plastic properties. 8 pages. The Richardson Co., 2750 Lake St., Melrose Park, Ill. J

Circle 647 on Page 19

Chemical Milling

Sixth in a series of bulletins will assist design personnel to gage what chemical milling can do for them. It discusses inspection stages, tolerances, and surface finishes obtainable on various metals. United States Chemical Milling Corp., 1700 Rosecrans Ave., Manhattan Beach, Calif. L

Circle 648 on Page 19

Adjustable Speed Drives

Rectiflow alternating-current adjustable speed drives are offered in 3:1, 2:1, and 1½:1 speed ranges and unit frame ratings from 7½ to 75 hp. How drives work, their applications, and performance and dimensions are reviewed in Folder B-7302. 6 pages. Westinghouse Electric Corp., Motor Dept., Buffalo 5, N. Y. F

Circle 649 on Page 19

Optics & Instrumentation

What optics are and where they can be used in control, measurement, light-transfer systems, and photographic processes are but a few of the subjects in beautifully-illustrated brochure. It is titled "Optics: The science which treats of light and the phenomena of vision." 16 pages. Consolidated Electrodynamics Corp., Spectron Transducer Div., 1725 Primrose Ave., Monrovia, Calif. L

Circle 650 on Page 19

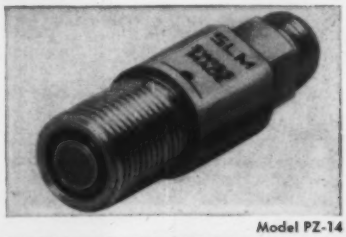
Metal Fabrications

Typical plate and sheet metal fabrications produced to customer specifications are shown and described in illustrated facilities booklet. Company is equipped to handle practically any contract fabricating job. 16 pages. Littleford Bros., Inc., 453 E. Pearl St., Cincinnati 2, Ohio. G

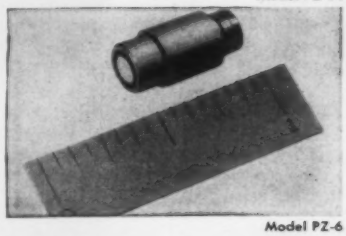
Circle 651 on Page 19

Engineering-Production

Presented as a pictorial review of the available engineering services and machine tools of this company, Booklet



Model PZ-14



Model PZ-6

Single Kistler Transducer Measures Pressures, Rates, Forces and Acceleration

Precise measurements of diverse pressures, pressure rates, differential pressures, forces, vibration and acceleration can now be made with one Kistler SLM Transducer.

Providing advanced instrumentation for engines, compressors, shock tubes, gun tubes, rockets, hydraulic and pneumatic systems, the self-generating, crystal-type *SLM Pressure Pickup (Model PZ-14)* performs as follows: Measures pressure or pressure rate *directly;* displays all pressures from full vacuum to 3000 psi (100,000 psi with adaptors); covers frequency range of 0 to 50,000 cps; operates continuously at 600° F; withstands intermittent gas temperatures to 3000° F; indicates .1 psi variations at any pressure level to 3000 psi; measures fast pressure transients; makes short term measurements of static pressures. The *SLM Miniature Pickup (Model PZ-6)*, of the same basic design as the *PZ-14 Pickup*, achieves response times approaching one microsecond.

Transient differential pressures can be measured precisely at distant points by using two SLM Pressure Pickups opposite polarity. When pickup cables are joined, signals automatically add or subtract. An Accelerometer Adaptor with a mass, spring-loaded against the crystals, converts the standard SLM Pickup into a precision *Acceleration-Vibration Indicator.* Static calibration is accomplished by turning it upside down in the earth's gravity field, generating a 2G signal.

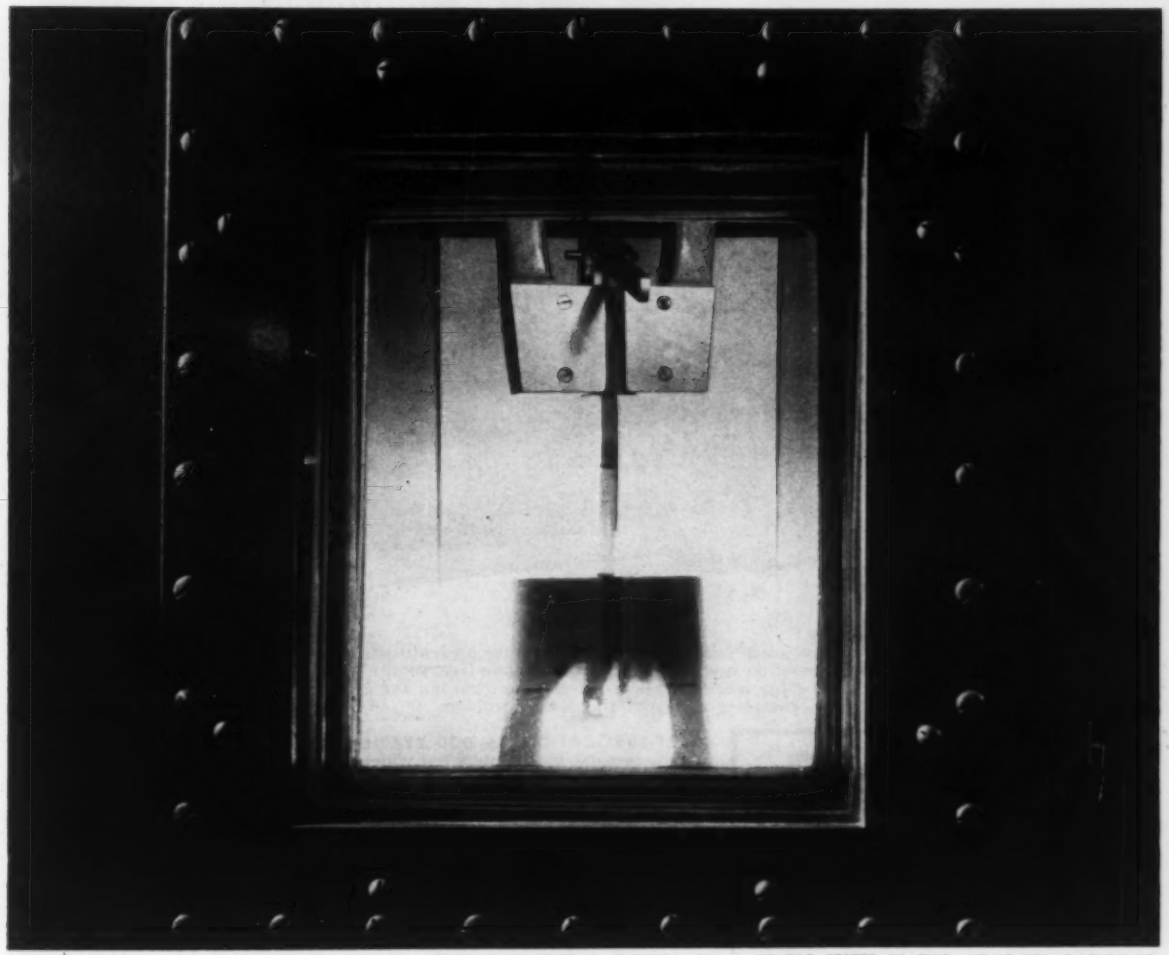
Utilizing a *Force Adaptor,* the SLM Pickup precisely measures forces to 300 lbs. with less than .005" deflection, and .1 lb. variations at any level. Larger forces may be accommodated by using several pickups with their signal leads joined.

SLM Pickups are coupled to oscilloscopes or recorders with electrostatic amplifiers *e.g.* Kistler Piezo-Calibrator-Amplifier units. A new Amplifier-Calibrator (Model PT-14), single or two-channel rack mounted, has fast response (0 to 200,000 cps), high gain (20), and low output impedance (7000 ohms). For complete information, request Bulletin S-114.

Kistler Instrument Corp., Dept. MD, 15 Webster St., North Tonawanda, N. Y.

Circle 486 on Page 19

Rugged 3M sandwich adhesive EC-1357 holds 315 psi at 200° F.



TORTURE CHAMBER. BONDING STRENGTH OF 3M ADHESIVE EC-1357 IS CHECKED ON A TENSILE TESTER IN THIS AIR-HEATED ENCLOSURE.

The two metal strips in this tug-of-war are bonded by a tough, heat-resistant 3M sandwich adhesive—EC-1357. On the tensile tester, under a dynamic loading of ½ inch per minute . . . and at searing temperatures as high as 200° F. . . . EC-1357 withstands a stress of over 300 psi.

Rugged grip . . . you bet! But more than that, because it is dark colored, EC-1357 dries faster under infrared heat, and you cut production costs by pre-drying for maximum immediate strength—or cold-bonding on a cold press or nip roller for fabricating at room temperature.

Its remarkably high resistance to moisture, high and low temperatures, and weathering make EC-1357 ideal for installations where climatic changes are sudden and severe. And EC-1357 is easy to spray-apply. Greatly reduced cobwebbing insures better surface-wetting for far better adhesion. And you save materials!

3M also offers EC-1368, a light colored version of EC-1357 which provides the same cold-setting, high strength bond.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU!

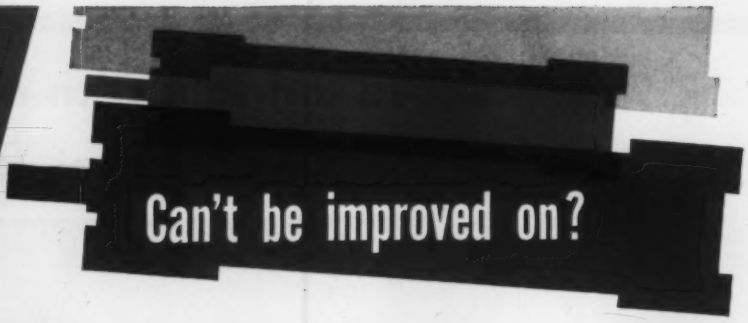
For full details contact our branch sales office near you. There are 19 located in principal cities throughout the United States ready to assist you in technical problems. Six plants provide local service for faster delivery. For free illustrated literature, write: 3M Company, Dept. C-6, 417 Piquette Ave., Detroit 2, Michigan.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

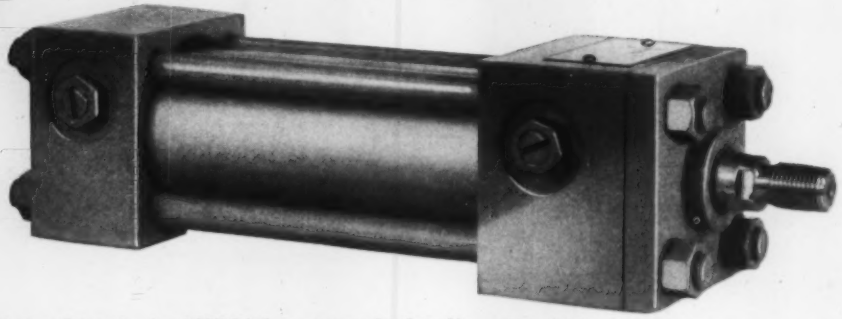
. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY



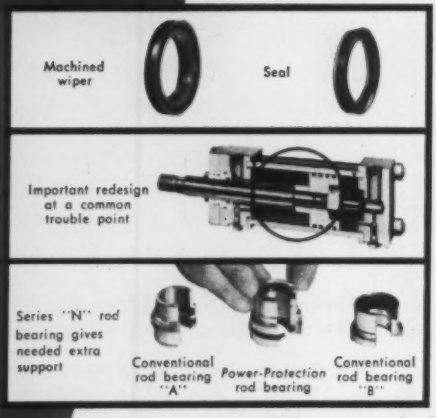
Can't be improved on?

NEW POWER-PROTECTION DESIGN OF SERIES "N" CYLINDERS EXTENDS EFFICIENT SERVICE LIFE 4 WAYS



Every Hydro-Line Series "N" high-pressure hydraulic cylinder is smoother operating and gives trouble-free, more efficient service for more high-speed cycles because it's the end result of a complete review of the design problem.

Bores 1-½ in. to 12 in. . . . 13 standard mounts . . . 2000-psi and higher operation


Machined wiper
Seal
Important redesign at a common trouble point
Series "N" rod bearing gives needed extra support
Conventional rod bearing "A"
Power-Protection rod bearing
Conventional rod bearing "B"

SELF-LUBRICATION OF ROD BEARING WITHOUT OIL LEAKAGE — this is made possible by the neoprene wiper and seal shown on the left. The flared lip of the seal, without mechanical holding against rod, permits a small amount of oil to cling to the rod and pass into the bearing for lubrication on the outstroke. Close-fitting machined inner edge of wiper eliminates leakage, wipes piston rod dry on the outstroke.

CLEANER INSTROKE — precision machining of the external edge of the neoprene wiper makes it an almost perfect barrier against dirt and air as the rod moves back inside the cylinder. Chances of scoring are minimized.

GROUND, HARD-CHROME-PLATED AND POLISHED PISTON ROD — the finish of the ground, hard-chrome-plated and polished piston rod not only makes it highly resistant to both scoring and corrosion, it also offers the perfect mating surface for the machined edges of the wiper. The combination of self-lubrication, dirt elimination, and the extreme hardness and smoothness of the rod surface gives you very important protection at one of the major trouble points in conventional cylinder designs.

BETTER ROD SUPPORT—Hydro-Line's "Power-Protection" design simplifies maintenance and gives extra rod support. Bearing "A" has its useful length reduced by cavity needed for 3-piece rod wiper assembly plus space for hat packing. Seal on bearing "B" is very close to rod wiper reducing bearing strength at critical outboard end.

Call your nearby Hydro-Line representative today — ask for demonstration of how *Power-Protection* design can give you longer trouble-free cylinder service life.

HL CYLINDERS

HYDRO-LINE MANUFACTURING COMPANY

5600 PIKE ROAD ROCKFORD, ILLINOIS

manufacturers of: high- and low-pressure hydraulic cylinders • heavy-duty air cylinders • adjustable-stroke cylinders • dispensing cylinders • intensifiers • single-acting cylinders • booster cylinders

10948 is entitled "Alcoa Fabricating Facilities." It depicts the diversified skills and equipment for designing, forming, joining, and finishing aluminum jobbing products. 16 pages. Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19, Pa. F

Circle 652 on Page 19

Speed Reducers

Hy-Torq speed reducers are available for fractional to 5-hp drives in single and double reductions with ratios up to 7225:1. Full details on these drives which fit on standard motors are given in bulletin. 4 pages. Barr Mfg. Co., 2790 W. Seventh Ave., Denver 4, Colo. K

Circle 653 on Page 19

Teflon O-Rings

Technical Bulletin TR-2772 gives full information on Teflon O-rings ranging in size from 3/32 to 15/16 in. OD and from ⅛ to ¾ in. ID. Service temperatures range from −450 to 550° F and pressures to 30,000 psi. 2 pages. Tri-Point Plastics, Inc., 175 I. U. Willets Rd., Albertson, L. I., N. Y. D

Circle 654 on Page 19

Small Vibrator

Details of the new small V-2 vibrator which is designed to vibrate small hoppers, tracks, and chutes of processing, assembling, and packaging machines are given in illustrated bulletin. Vibrator is electromagnetic. Syntron Co., 260 Lexington Ave., Homer City, Pa. F

Circle 655 on Page 19

Magnesium Alloy

Complete technical and application data on HK31A magnesium alloy plate and sheet is set forth in Bulletin 141-174. Design, mechanical, fabrication, and other properties are detailed. 36 pages. Dow Chemical Co., Magnesium Dept., Midland, Mich. H

Circle 656 on Page 19

Variable Transformers

Described in Bulletin SE-L2583 are 10 and 6.3-amp Powerstat variable transformers which will deliver continuously-adjustable voltages from alternating current power lines. Types are available for 120, 240, or 480-v, single or three-phase duty. 4 pages. Superior Electric Co., Dept. 117, Bristol, Conn. B

Circle 657 on Page 19

Multispeed Reducer

Made in torque capacities up to 1150 oz-in., Multi-Speed gear reducers can be adjusted to a sequence of values by setting the control knob. They can also be adapted for remote control. Practically any desired reduction ratio can be supplied. Details are given in Bulletin 358. 8 pages. Haxton Gear Co., 7-11 Main St., East Rockaway, N. Y. D

Circle 658 on Page 19

Four-Way Valve

Intended for use in analysis circuits, Models P1-418 and P2-418 four-way selector valves will handle pressures to 100

An endless parade of electrically perfect, wired terminals with absolutely identical performance characteristics is assured when A-MP non-insulated Diamond Grip terminals are used. No matter how many terminals you need, each action of the A-MP precision tool attaches a Diamond Grip terminal that gives firm, fully circumferential wire support, for maximum tensile strength, resists vibration and corrosion, while performing at maximum conductivity.

The reason for these never-varying features is the exact crimping operation which pressures the wire into one homogeneous mass and permanently bonds it to the terminal. Wire size range is from No. 26 to No. 10. Important, too, are the lower installed costs of Diamond Grip terminals when compared to other methods of wire termination.

No matter what your termination problem is, our engineering services are available to you anywhere in the free world.

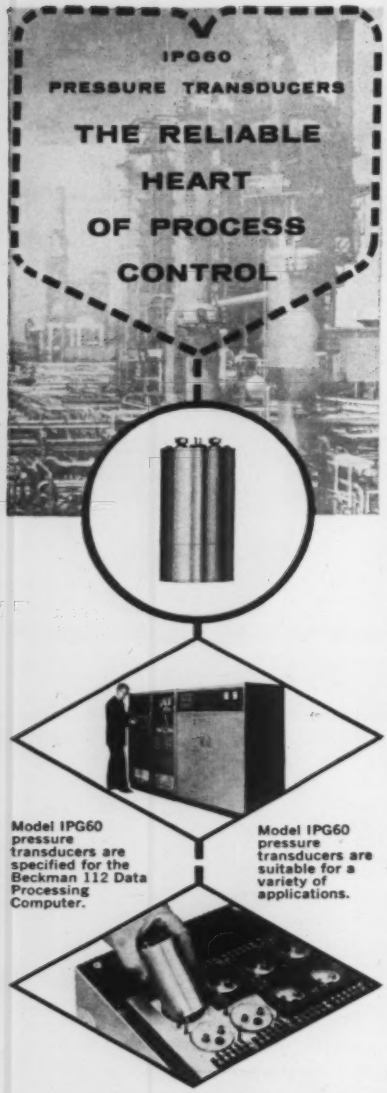
For complete specifications, write for our Diamond Grip Terminal and Connector catalog.

AMP INCORPORATED

General Offices: Harrisburg, Pennsylvania

A-MP products and engineering assistance are available through wholly-owned subsidiaries in: Canada • England • France • Holland • Japan

Circle 489 on Page 19



Model IPG60 pressure transducers are specified for the Beckman 112 Data Processing Computer.

Model IPG60 pressure transducers are suitable for a variety of applications.

The evolution of industry toward automation has created a demand for precision data handling systems such as the Beckman 112 Data Processing Computer. Statham Model IPG60 pressure transducers are specified in this system, providing basic information signals which are accurate within ±¼%. Complete data on the Model IPG60, or information on other Statham instruments, are available upon request.

RANGE: 0 to +15 psig.
PRESSURE MEDIA: Non-corrosive fluids
OUTPUT: Approximately 35 mv. full scale at 14 V. excitation
NON-LINEARITY & HYSTERESIS: Not more than ±0.25% of full scale

Statham

STATHAM INSTRUMENTS, INC. of Puerto Rico
254 Carpenter Rd., Hato Rey, Puerto Rico
Cable Address: STATRICO
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12401 W. Olympic Blvd., Los Angeles, California

Circle 490 on Page 19

HELPFUL LITERATURE

psi and temperatures to 280° F. Typical circuits are shown in Form 65-2236. 2 pages. Circle Seal Products Co., 2181 E. Foothill Blvd., Pasadena, Calif. L

Circle 659 on Page 19

Die-Casting Alloys

Guidance in the selection and application of Di-Metal die-casting alloys is offered in illustrated data book. Sections list specifications, metallurgy, and procedures. 32 pages. American Smelting & Refining Co., 120 Broadway, New York 5, N. Y. D

Circle 660 on Page 19

Casters & Wheels

Complete information on the Rapistan line of casters and wheels is contained in revised catalog. Specification tables give rated capacities, types of wheels, weight, and model numbers. 32 pages. Rapids-Standard Co., 342 Rapistan Bldg., Grand Rapids 2, Mich. H

Circle 661 on Page 19

Synthetic Belting

Texalon belting is made of a combination of woven textile and flat ribbons of extruded nylon, welded together into a strong flexible unit. Illustrated bulletin suggests applications, tabulates physical properties, and contains horsepower ratings and arc of contact correction factors. 6 pages. J. E. Rhoads & Sons, Wilmington 99, Del. C

Circle 662 on Page 19

Profile Rolled Shapes

Technical Data Bulletin IND-2 lists applications, material analysis, available sizes, and other information on GP profile rolled shapes of brass, aluminum, alloy steels, Hastelloy, titanium, and other metals. 4 pages. Metals & Controls Corp., General Plate Div., Attleboro, Mass. B

Circle 663 on Page 19

Hose Assemblies

Technical Bulletin 200 is devoted to design and application information on high pressure hose and tube assemblies for hydraulic and fluid service. Nine major sections deal with couplings suited for all types of hydraulic uses. Selection data aid in specifying proper assemblies for every condition. 32 pages. Eastman Mfg. Co., Manitowoc, Wis. K

Circle 664 on Page 19

Radial & Roller Bearings

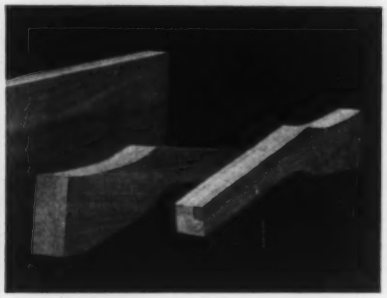
Sizes, capacities, and typical applications are some of the information presented in Catalog 58 on radial and roller bearings. Included are data on load ratings and bearing life, performance factors, and technical details. 64 pages. Messinger Bearings, Inc., 3727 D St., Philadelphia 24, Pa. E

Circle 665 on Page 19

Electric Heating Elements

Described in 1958 Catalog is a complete line of precision cartridge heating units ranging in diameter from ¼ in.

WHAT'S YOUR WOOD PROBLEM?



Gamble research even improves RIFLE MARKSMANSHIP!

THE PROBLEM. Expert rifle marksmen found that the slightest swelling or shrinking of their rifle stocks destroyed accuracy and created a variable pattern. To remedy this, a New York custom gun stock manufacturer turned to Gamble Brothers.

THE RESULT of Gamble development and testing: vertically laminated walnut gun stock blanks that provide greater strength, greater dimensional stability, less tendency to warp, and freedom from internal stresses. Chances are, Gamble could help with *your* wood problem.

Send for FREE booklet Illustrating GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Bros. Inc., 4619 Allmond Ave., Louisville 9, Ky.

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Circle 491 on Page 19

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- **3.5 or 5 gpm Models at 3000 psi**
- **8 ma Differential Current for Rated Flow**
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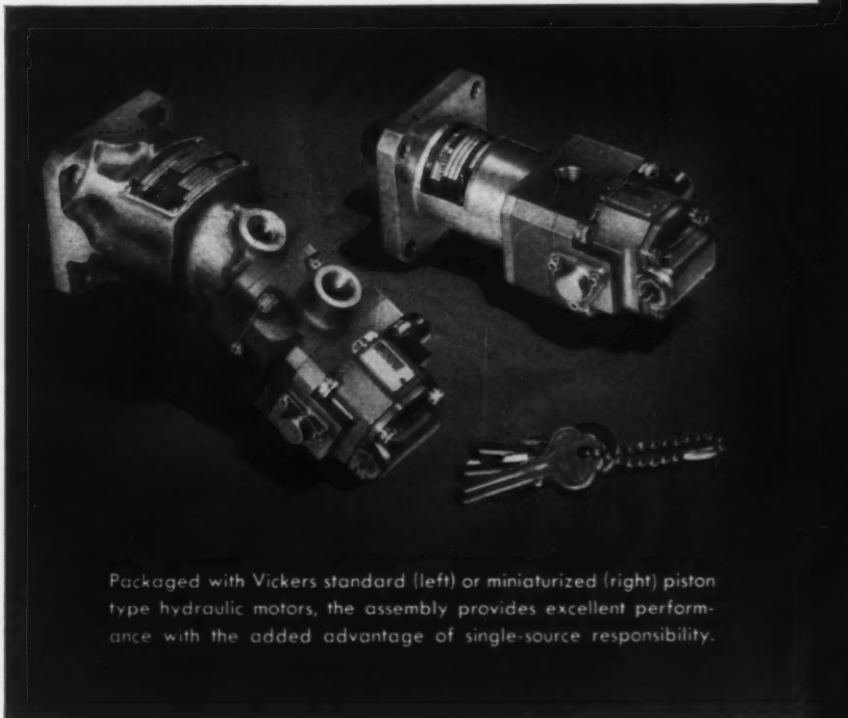
ACTUAL SIZE

New VICKERS® SERVO VALVE

Designed primarily for aircraft and missile applications, the new Vickers Electro-Hydraulic Servo Valve has numerous features (see above) that assure optimum performance and dependability.

Porting modulated flow to linear or rotary actuators with respect to minute input current has been optimized within a small envelope and at a weight that is approximately 30% less than other valves of similar capacity. Design also provides for interchangeability with many existing servo valves now used in airborne applications. For further information, ask for technical bulletin number SE-98.



Packaged with Vickers standard (left) or miniaturized (right) piston type hydraulic motors, the assembly provides excellent performance with the added advantage of single-source responsibility.

7977

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DIVISION OF SPERRY RAND CORPORATION

Aero Hydraulics Division • Engineering, Sales and Service Offices:

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Circle 492 on Page 19

TELEGRAMS: Vickers WUX Detroit, TELETYPE: "ROY" 1149 • CABLE: Videt
OVERSEAS REPRESENTATIVE: The Sperry Gyroscope Co., Ltd.—Great West Road, Brentford, Middx., England

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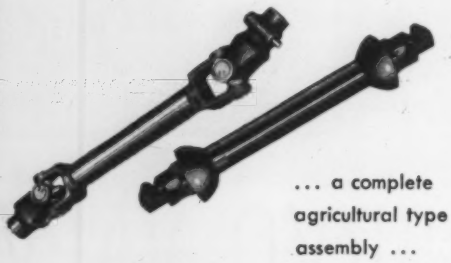
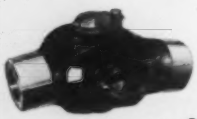
BLOOD BROTHERS works with you to HELP CUT COSTS

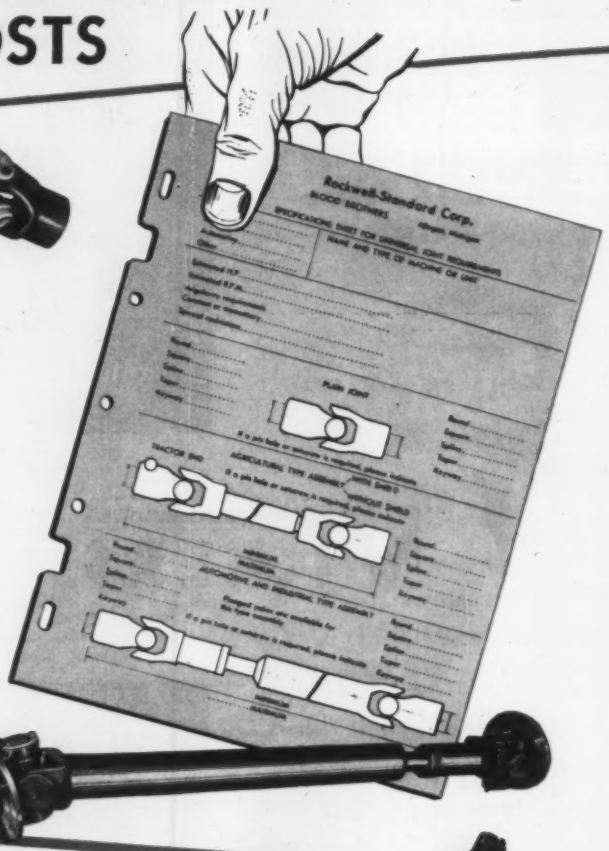
... when your project requires a simple universal joint like this ...



... a complete agricultural type assembly ...



... or automotive and industrial units like these:



YOU CAN SAVE MONEY TWO WAYS:

ONE—Have Blood Brothers review *all* joint and drive line specifications and costs for your *current models*. You'll help *insure* the lowest-cost purchasing of components that fulfill specifications. It's easy to submit data on "Spec Sheets" like that above—or if you wish, send us your engineering drawings.

> For example, one maker of eight types of machines cuts costs by using only three sizes of joints. This means smaller inventories, fewer parts to catalog and stock, and volume prices.

TWO—Save time at the start of new projects by sending us a "Spec Sheet" with your data. Our engineers will submit drawings and recommendations that may forestall problems later.

Blood Brothers builds more standard types and sizes of universal joints than any other manufacturer—and will gladly work with you to help cut costs.

Just write or call—and request your supply of handy blank "Spec Sheets" for use now or later.

ROCKWELL-STANDARD CORPORATION
(Formerly Rockwell Spring and Axle Company)

Blood Brothers Universal Joints

ALLEGAN, MICHIGAN

UNIVERSAL JOINTS
AND DRIVE LINE
ASSEMBLIES

© 1958, Rockwell-Standard Corp.

and up. They can be made to meet customer needs as to output, voltage, and current ratings. 12 pages. Hotwatt, Inc., 16 Gould St., Danvers, Mass. B

Circle 666 on Page 19

Stainless Steel Pumps

Specifically designed for corrosive and chemical service, a series of centrifugal pumps is of stainless steel construction. They will handle fluid temperatures up to 400° F and are made with 2 to 6-in. diameter inlets and 1¼ to 4-in. diameter outlets. Details on these pumps and their performance are given in Bulletin 258-1. 8 pages. Ladish Co., Tri-Clover Div., Kenosha, Wis. K

Circle 667 on Page 19

Decimal Chart-Calendar

Combination decimal equivalent chart and July 1958 through June 1959 calendar is printed in two colors for ease of use. Large, readable figures are used on this 12 x 30-in. wall-mounting design aid. Dayton Rogers Mfg. Co., 2824 Thirteenth Ave. S., Minneapolis 7, Minn.

Circle 668 on Page 19

Fine Wire

Use of diamond dies to draw wire to a bright, uniform finish is described in Booklet 358. Wire is drawn as small as 0.001 in. Plated wire and ferrous, nonferrous, and precision metal wire are also covered, as are all available types and gages. 8 pages. Nessor Alloy Products Co., 282 Halsey St., Newark 2, N. J. D

Circle 669 on Page 19

Switching Reactors

Standard switching reactors for one-step, low-cost static control are described in Catalog S-10. Adaptable to ac or dc use, they perform all logic functions and are applicable to switching and sequencing. Ratings from 15 to 300 va are covered. 12 pages. Magnetics, Inc., Control Div., Butler, Pa. F

Circle 670 on Page 19

Silicone Rubber

Silastic RTV 501 silicone rubber, subject of data sheet 9-384, vulcanizes at room temperature to form a silicone rubber with good resistance to weathering, moisture, heat, and cold. Characteristics and typical properties are given. 2 pages. Dow Corning Corp. Midland, Mich. H

Circle 671 on Page 19

Copper-Clad Plastic

"A Better Foundation for Printed Circuitry" is title of an illustrated booklet which deals with copper-clad Phenolite, a laminated plastic offered in 11 grades for use in printed circuits. Typical test values are given in tabular form. 6 pages. National Vulcanized Fibre Co., 1058 Beach St., Wilmington 99, Del. C

Circle 672 on Page 19

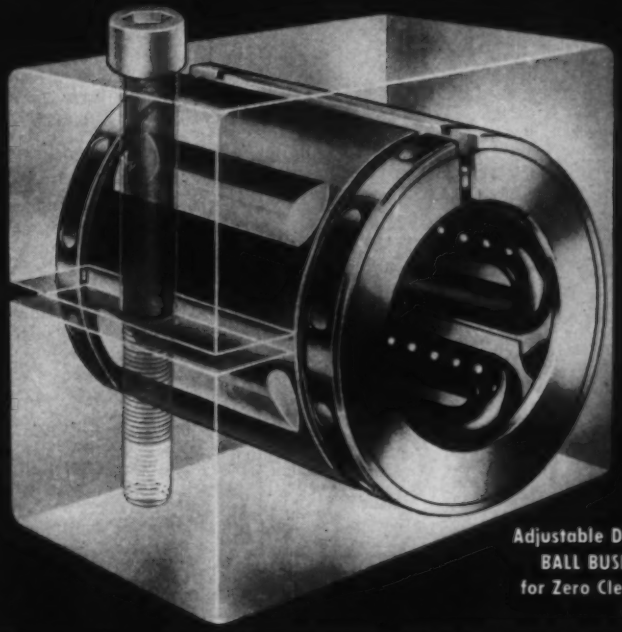
Measuring Valves

Systems for dispensing measured quantities of fluid and semifluid materials

Circle 494 on Page 19→

NOW! Adjustable Diameter and Open THOMSON

BALL BUSHINGS



Adjustable Diameter BALL BUSHING for Zero Clearance

The BALL Bearing for *all* your LINEAR MOTIONS

Precision Series "A" and Low Cost Series "B" BALL BUSHING

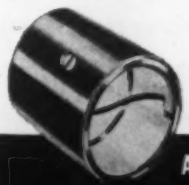
Open BALL BUSHING for Zero Clearance on Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

LOW FRICTION • ZERO SHAKE OR PLAY
ELIMINATE BINDING AND CHATTER
SOLVE SLIDING LUBRICATION PROBLEMS
LONG LIFE • LASTING ALIGNMENT

The various types cover a shaft diameter range of ¼" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.

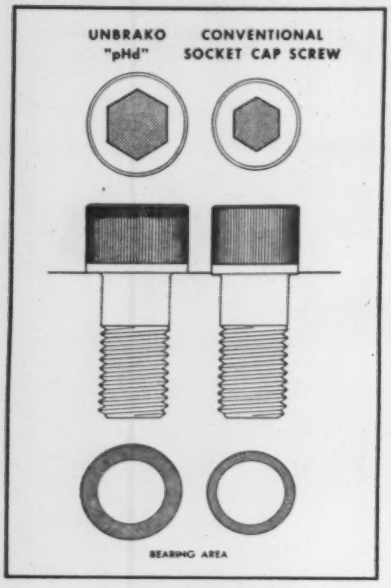


THOMSON INDUSTRIES, Inc.
Dept. E, MANHASSET, NEW YORK

Also Manufacturers of NYLINED Bearings . . . Sleeve Bearings of DuPont Nylon, and 60 CASE . . . Hardened and Ground Steel Shafting

NEW UNBRAKO socket cap screws with *pHd**

Another Unbrako first providing higher reliability through greater usable fastener strength



***pHd stands for "proper head design"—a factor in higher product reliability**

Enlarged bearing area surface of new design increases holding power of screw up to 2⅓ times. The new design is the end product of extensive study of bolt-bearing stresses by SPS Laboratories. This research was sparked initially by the relatively high incidence of fastener failures, later traced to fatigue, in certain cap screw sizes. These sizes proved to have head diameters and other design characteristics which, though standard for many years, could not utilize the full strength of the screw.

UNBRAKO pHd—UP TO 134% INCREASE IN USABLE STRENGTH

The head size increase, a maximum of only 17% in the larger sizes, increases usable fastener strength as much as 134%. In tension bolting—primary application of socket cap screws—this means greater clamping force and longer life under dynamic loads. The heads, enlarged on 5/16, 7/16, 9/16, 5/8, 3/4, 7/8 and 1 in. body diameters, also prevent the screw head from indenting the material being assembled —a fault that normally reduces, and sometimes completely dissipates, the vital preload or tensile stretch that keeps the screw tight and prevents fatigue failure. The larger head diameter of the new UNBRAKO pHd also provides room for a bigger wrenching socket where required and this, in turn, makes tightening to designed tensile preload easier and safer.

SPS enlarged the head diameters to hold the bearing stress to 80% of the axial tensile load on the screw. The bearing stress of a screw loaded to 100,000 psi would be a maximum of 80,000 psi. Recommended installation torques to attain this initial tightening are substantially higher than for standard socket cap screws.

COMPARISON OF UNBRAKO pHd AND CONVENTIONAL DESIGN

Each size can now be utilized with equal reliability. The bearing stress is consistent from size to size in the new UNBRAKO pHd socket cap screws.

SCREW SIZE	HEAD DIAMETER (in.)		BEARING AREA (sq. in.)		LOAD TO INDENT IN CAST IRON (lb.)		% INCREASE USABLE STRENGTH	TIGHTENING TORQUE (lb.-in.)*	
	Old	pHd	Old	pHd	Old	pHd		Old	pHd
¼	.375	.375	.041	.041	3,280	3,280	—	165	180
5/16	.435	.468	.047	.072	3,760	5,760	54	325	360
⅜	.560	.560	.102	.102	8,150	8,150	—	600	660
7/16	.623	.656	.116	.148	9,270	11,800	27	1,000	1,040
½	.748	.748	.188	.188	15,000	15,000	—	1,450	1,590
9/16	.810	.843	.209	.247	16,700	19,700	18	2,050	2,270
⅝	.873	.973	.203	.305	16,200	24,400	51	2,900	3,190
¾	.998	1.125	.223	.432	17,800	34,600	94	5,050	5,600
⅞	1.123	1.312	.254	.594	20,300	47,500	134	8,000	8,900
1	1.310	1.500	.364	.785	29,100	62,800	116	10,550	13,600

*Normal recommended seating torques for unplated screws, fine threads

hiRf
High Reliability factor

Research at SPS is realistic, for it faces the fact that industry is always seeking structural and mechanical components with higher and higher standards of predictable performance. By installing SPS high reliability fasteners in your assemblies, you increase overall product reliability.

"High Reliability" is a booklet just published by SPS. Write for your copy today.

ADVANTAGES OF THE NEW UNBRAKO pHd SOCKET HEAD CAP SCREWS

- **Miniaturization.** Space and weight-saving design through use of smaller diameter or fewer fasteners. The 180,000-200,000 psi of these fasteners can be utilized to greater advantage.
- **Reduction of fatigue failure,** because these cap screws assure the necessarily high preload. Lack or loss of it is responsible for some 75% of threaded fastener failures.
- **Fewer loosened threaded fasteners** under shock or vibration.
- **Elimination of washers** under the heads of cap screws in many applications where they are now used to increase the effective bearing area.
- **Minimization of effects of oversized holes** on the head bearing area and resulting increase of holding power.

The new UNBRAKO pHd socket head cap screw is now available through all authorized industrial distributors at no increase in price. Specify UNBRAKO pHd when you order. For technical data and specifications, send for Bulletin 2406. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

We also manufacture precision titanium fasteners. Write for free booklet.

SPS **Jenkintown • Pennsylvania**

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

are described in illustrated Bulletin 682. Their rapid recovery speeds up assembly operations in automated operations. Engineering data on various valve types are presented. Lincoln Engineering Co., 5736 Natural Bridge Ave., St. Louis 20, Mo. I

Circle 673 on Page 19

Metal & Plastics Processes

Design and production data are given for die casting, stamping, precision machine parts, metal forming, plastic molding, welding, assembly, automatic plating, automatic polishing and buffing, painting, and die making in an illustrated folder on plastics and metal processes. 8 pages. Ainsworth-Precision Castings Co., 3200 Guardian Bldg., Detroit 26, Mich. H

Circle 674 on Page 19

Hydraulic Servo Drives

Packaged hydraulic servo drives which offer a precision response to a small signal characteristic of servo hydraulic and electro-hydraulic systems are detailed and illustrated in Bulletin AI-5801. Application to varied military equipment is covered. 12 pages. Vickers Inc., Detroit 32, Mich. H

Circle 675 on Page 19

Explosionproof Motors

Nonventilated and fan-cooled explosionproof motors, subject of illustrated Bulletin 1200, are UL-approved for use in various hazardous locations. Their construction is detailed and specifications are presented, 8 pages. Fairbanks, Morse & Co., 600 S. Michigan Ave., Chicago 5, Ill. I

Circle 676 on Page 19

Ceramic Grate Magnet

Wing type for floor opening or hopper installation and drawer type for chutes and ducts are types of Indox ceramic grate magnets discussed in illustrated Data Sheet P-1072. Single or double bank collecting tube models are covered. 2 pages. Indiana Steel Products Co., Stearns Magnetic Products Div., 635 S. 28th St., Valparaiso, Ind. K

Circle 677 on Page 19

Crane Rails

Illustrated Catalog 464 describes the manufacture of crane rails as differentiated from railroad rail. Directions for jointing, welding, selection of proper section are included, as are a number of diagrams and tables. Detailed specifications are also included. 24 pages. Bethlehem Steel Co., Bethlehem, Pa. C

Circle 678 on Page 19

DC Power Supplies

Brochure E-58 catalogs a complete line of direct-current power supplies, alternating-current line regulators, and static inverters. Many of the items shown are used in airborne radar and missile applications. 8 pages. Send request for catalog on company letterhead to Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif. L

TOUGH
and tiny
Save SPACE
and WEIGHT with
The A. W. HAYDON COMPANY'S unique Line of
RELIABLE SUB-MINIATURE REPEAT CYCLE TIMERS
TINY!
1 x 2 inch cross section
6½ ounce basic weight
Up to 10 switches
TOUGH!
Temperature 54 C to 85 C
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Shock 30g
Hermetically Sealed Housings! Direct Current or 400 Cycle Operation! Custom Designed to Meet Military Specifications! Write for Bulletin AWH-RC-301.
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Design and Manufacture of Electro-Mechanical Timing Devices

Circle 496 on Page 19

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pneumatic regulating valves and amplifying volume booster relays
STRATOS
of Kendall—
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precision pneumatic
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The facts you need on a complete range of pneumatic pressure regulating valves and volume boosters. Here is your guide to a series of pilot-operated and direct acting regulators—in pipe sizes from ¼ to ⅜ and ¾ NPT...in supply pressures up to 250 psi. Fact-filled pages spell out the full story: characteristics • pressure ranges, ratios • applications—for 16 different models including motor operated and lever set types.
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A DIVISION OF FAIRCHILD ENGINE & AIRPLANE CORPORATION
Turbo-Expanders and Compressors
SPECON Variable Speed Drives and Transmissions
Pneumatic Pressure Regulators

Circle 497 on Page 19

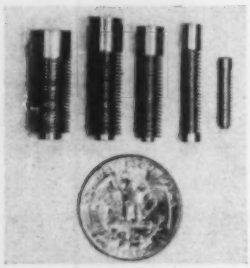
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Miniature Metal Bellows

have wall thickness down to 0.0008 in.

Metal bellows in sizes from 1 to 0.125 in. OD are available in any wall thickness down to 0.0008 in. Metal is a nickel alloy of high tensile strength and low hysteresis which resists both corrosion and temperature. Typical unit has 0.125 in. OD, 0.0008 in. wall thick-



ness, 16 convolutions, 0.4 in. active length, 0.04 in. stroke, and 12 lb per in. spring rate. Applications include bellows-operated thermostats, bellows-packed valves, hermetic rotary seals, and pressure transducers. **Servometer Corp.**, P. O. Box 42, Clifton, N. J. D

Circle 679 on Page 19

Gear Reducer

is available in 24, 32, 48, and 64 pitch

New six-station gear reducer produces an almost unlimited variety of reduction ratios. Selector knob changes ratio smoothly, even while unit is running under full load. Model BB has ball bearings on all rotating members, and Model DR has ball bearings on input and output shafts. Starting torque of the BB is ¾ oz-in., no load, with recommended maximum input speed of 4500 rpm. Starting torque of the DB is 1½ oz-in., no load, with 1800 rpm maximum input speed. Four basic gear pitches are 24, 32, 48,

and 64 pitch. Gears are 416 stainless steel, cut to AGMA Precision Class 2. **Haxton Gear Co.**, 7-11 Main St., East Rockaway, N. Y. D

Circle 680 on Page 19

Textured-Aluminum Sheet

has surface similar to sanded sheet

New textured-finish aluminum sheet, designated Reytex, gives a uniform mat surface on which scratches and other minor surface abrasions are less noticeable than on other surfaces. Sheet has applications in automobile trim, appliances, furniture, stove hoods, decorative materials, and novelties. The product, which has a surface similar to sanded sheet, is available in all standard sizes. **Reynolds Metals Co.**, 2500 S. Third St., Louisville, Ky. G

Circle 681 on Page 19

Spring Washer

is nonslip, antivibration unit

New Sawtooth Belleville washer supports static loads where spring action is required and resists vibration where a dynamic load is being

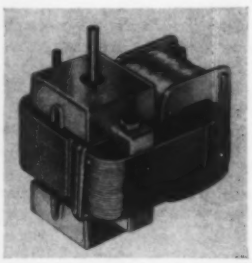
exerted in several directions. Available in standard and special sizes, washer is for use in the automotive, electronic, home appliance, aviation, and associated industries. It is of heat-treated, high-carbon steel, low-carbon steel, stainless steel, bronze, or aluminum. **George K. Garrett Co. Inc.**, Torresdale Ave. at Tolbut St., Philadelphia 36, Pa. E

Circle 682 on Page 19

Shaded-Pole Motor

in 1/550 to 1/50-hp models

New two-pole, shaded-pole motor, Model H, is designed for applications requiring long service life. Oil-saturated packing assures even lubrication at all times. Rugged, die-cast bearing bracket insures precision alignment and adds to durability. Motor is available in nine models ranging from 1/550 to 1/50 hp. They can be used with a variety of drives in applications such as small fans and blowers, phonograph turntables, floor heaters, pro-



jectors, centrifugal pumps, appliances, vending machines, and communications equipment. **General Industries Co.**, Elyria, Ohio. G

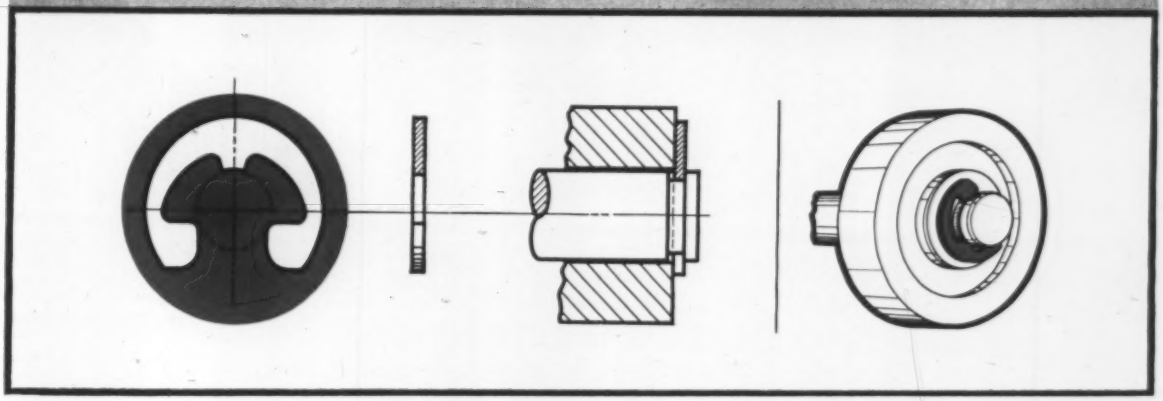
Circle 683 on Page 19

Floating Shaft Coupling

for miniature applications

No. 50 CE special floating shaft coupling is available in full and semifloating styles. Floating shaft is held concentric by flexible disc

New Waldes Truarc Reinforced "E-ring" Provides 5 Times More Gripping Power, 50% Higher RPM Limits Than Conventional E-Type Rings



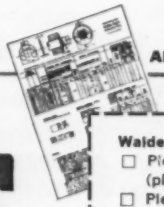
The new Waldes Truarc Series 5144 is a radially-installed reinforced "E-ring." It is designed for use in assemblies where the ring is subject to strong push-out forces resulting from heavy vibration and shock loads, high rotational speeds or relative rotation between the retained parts.

Series 5144 provides the following application advantages over conventional E-type fasteners:

1. **GREATER GRIPPING STRENGTH**—approximately five times greater than conventional "E-rings" of the same metal and thickness.
2. **HIGHER RPM LIMITS**—approximately 50% higher in most sizes.
3. **POSITIVE LOCKING IN THE GROOVE**—large corner radii or chamfers can be accommodated without separator washers.
4. **LOWER GROOVE COSTS**—because recommended groove tolerances have been increased, machining grooves for the series 5144 is less expensive.
5. **WIDER APPLICATION**—because series 5144 rings made of aluminum are stronger than conventional "E-rings" made of steel, the fastener may be used in applications where corrosion resistance or weight are factors.

Truarc Series 5144 Reinforced "E-rings" are available for shaft diameters from 3/32—7/16 in. in carbon spring steel, stainless steel, beryllium copper, aluminum, and phosphor bronze. They are available stacked on rods for high speed installation with Truarc applicating and dispensing equipment.

As in all Truarc rings, you get statistically controlled quality from engineering and raw materials to the finished product. Complete selections are available from leading OEM distributors in 90 stocking points throughout the U. S. and Canada. Design Engineering Service is available to you. Send us your blueprints. Let our Truarc engineers help you solve design, assembly and production problems... without obligation.

SEND FOR FREE SAMPLES  **AND ENGINEERING DATA**

WALDES

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WALDES KOHINOOR, INC., LONG ISLAND CITY 1, N. Y.

Waldes Kohinoor, Inc., 47-16 Austel Place, L.I.C. 1, N.Y.

☐ Please send me sample Reinforced "E-rings." (please specify shaft size)_____

☐ Please send me Engineering Data Sheet

Name_____

Title_____

Company_____

Business Address_____

City_____ Zone_____ State_____

MD-060

Consult the Yellow Pages of Your Telephone Directory for Name of Local Truarc Factory Representative and Authorized Distributor. Look under "Retaining Rings" or "Rings, Retaining."

Resets at a Finger-FLICK...

runs at speeds up to 8,000 counts per minute!

Here's a new Veeder-Root high-speed predetermining counter *with instant resetting*. Easily preset to the required number of pieces or performance-units, the counter subtracts to zero . . . *then resets with a finger-flick back to the original preset number.*

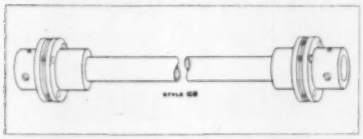
This new counter meets standard U. S. electrical requirements (JIC Codes) . . . and is available with either electrical switch or mechanical stop. Also available *without the predetermining feature*, as a high-speed reset revolution counter. Series 1522 High Speed Predetermining Counters come in a rugged, handsome 2-tone gray case that looks well everywhere. *Write:*

EVERYONE CAN COUNT ON

Veeder-Root
INCORPORATED
Hartford 2, Connecticut

*Trade-mark registration applied for.

Hartford, Conn. • Greenville, S. C. • Altoona, Pa. • Chicago • New York • Los Angeles • San Francisco • Montreal • *Offices and Agents in Principal Cities*



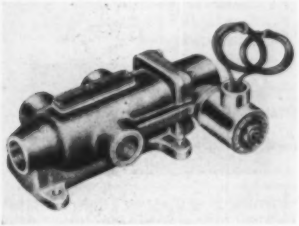
rings at both ends. Shafts are either solid or tubular. Coupling can be used with semifloating couplings to permit use of long power-transmission shafts with a minimum of bearings. Semifloating shaft has a single flexing coupling on one end; other end is supported by an outboard bearing. Semifloating shaft unit breaks up bending moment caused by misalignment in spans of three or more bearings. **Thomas Flexible Coupling Co.**, Warren, Pa. F

Circle 684 on Page 19

Four-Way Valves

are solenoid actuated

New four-way solenoid-actuated valves are available in single or double solenoids and are furnished with (shown) or without sub-base. Designed for easy actuation, they are suitable for operating double-acting cylinders. Valves are available for 110, 220, or 440 v ac in ¼, ⅜, ½, and ¾-in. NPT sizes. They



are suitable for continuous or intermittent duty. **A. Schrader's Son, Div., Scovill Mfg. Co. Inc.**, 470 Vanderbilt Ave., Brooklyn 38, N. Y. C

Circle 685 on Page 19

Silicon Transistors

for high-power switching operations

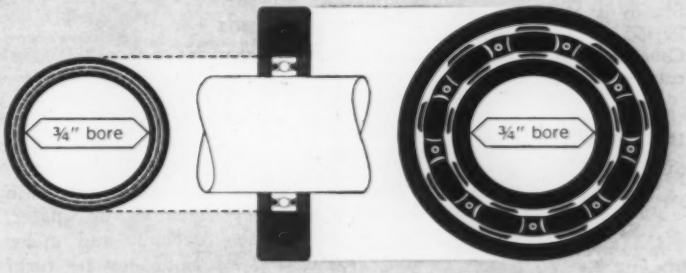
New series of silicon transistors includes two n-p-n fused-junction devices, a 2 to 5-amp unit that handles power to 1 kw, and a 10 to 20-amp unit to handle power to 3 kw. The 2 to 5-amp transistors have emitter-to-collector voltages of 50 to over 300 v. The high voltages and currents, coupled with low saturation

how to conquer space

Compact design of instruments and other precision mechanisms calls for critical evaluation of all components in terms of the *space* they require.

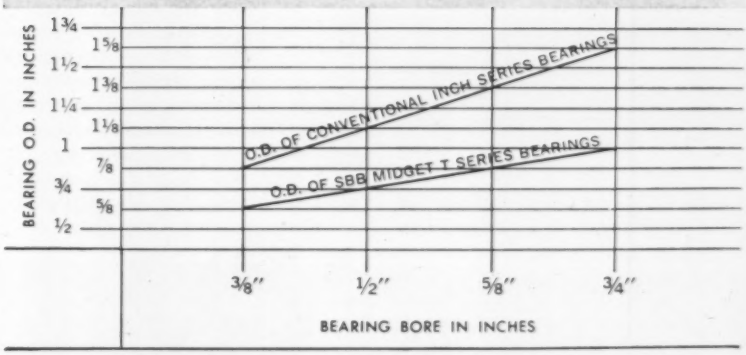
SBB Midget T Series ball bearings can reduce space requirements from 66% to 90% by replacing conventional inch series ball bearings. On basis of ratio of bearing volume to load capacity they are twice as efficient as conventional ball bearings of equivalent bore size. Low torque values, too.

Save up to 46% on O.D. and up to 90% on total volume.



3TCR 12-16 MIDGET T SERIES

CONVENTIONAL BALL BEARING— INCH SERIES



Write today for brochure on Midget T Series.

split ballbearing
A DIVISION OF MPB, INC.

302 HIGHWAY FOUR
LEBANON, N. H.

Circle 500 on Page 19

keep hydraulic valves free and functioning properly . . . . .

FERRO FILTER

MAGNETIC SEPARATORS

Shown is high pressure model P2H50 for service to 5000 psi. Other models for low pressure rated at 100 psi.

And Here's How It's Done

Fluid passes through a stack of grids (lower right) magnetized by two powerful Alnico magnets (upper right, lower left). The "honeycomb" design of the grids splits the flow into thin streams, allowing fine particles of iron, rust and scale to be caught and held on the grid edges.

Send for BULLETIN PM-83

S. G. FRANTZ CO., INC.

Brunswick Pike & Kline Ave.
P. O. Box 1138 Trenton 6, N. J.

Circle 501 on Page 19

resistances, permit use of the transistors for high-power switching operations with high efficiencies. Transistors can be used at temperatures up to limits imposed by silicon material itself. Voltage ratings on 10 to 20-amp units range

from 50 to 150 v. High current and voltage ratings represent high-power handling capacities if internal dissipation is low. Used as a dc switch, the units handle 3 kw with internal losses of less than 20 w. Westinghouse Electric Corp., Box 2278, Pittsburgh, Pa. F

Circle 686 on Page 19

Rod Ends

bonded-rubber units need no lubrication

Bonded-rubber rod ends provide excellent absorption of shock and impact loads, isolate vibration, and need no lubrication. Consisting of an inner member or spacer, an alloy-steel eyebolt, and a bonded flexing element, they are furnished with threads for either externally or internally threaded rods. The rod ends carry tension or compression loads, assure quiet operation, and introduce beneficial damping and small spring return forces. They accommodate misalignment and dimensional deviations, permitting larger tolerances in attaching parts. Torsional deflections to ± 30 deg and angular deflections to ± 7 deg are normally provided, with variations of ± 50 per cent in

D.O.James *Established 1888*

RIGHT ANGLE GEARMOTORS MOTOREDUCERS

TYPE "R"

RIGHT ANGLE GEARMOTOR — Horizontal or Vertical Drive, 8 sizes, ratio 6:1 to 100:1, ⅓ to 30 horsepower.

TYPE "RS"

RIGHT ANGLE MOTOREDUCER— Horizontal or Vertical Drive, 8 sizes, ratio 6:1 to 100:1, ⅓ to 30 horsepower.

OUR 70th YEAR

THESE D.O.James Right Angle Gearmotors and Motoreducers are of the same construction and high quality as the individual Gear Speed Reducers which we have been producing for so many years. They cover a very wide range of ratios, horsepowers, and are an ideal, compact, efficient unit for many power and space-saving installations.

D.O. JAMES GEAR MANUFACTURING CO.
1140 W. Monroe Street, Chicago, Illinois

Since 1888

MAKERS OF EVERY TYPE OF GEAR AND GEAR SPEED REDUCER

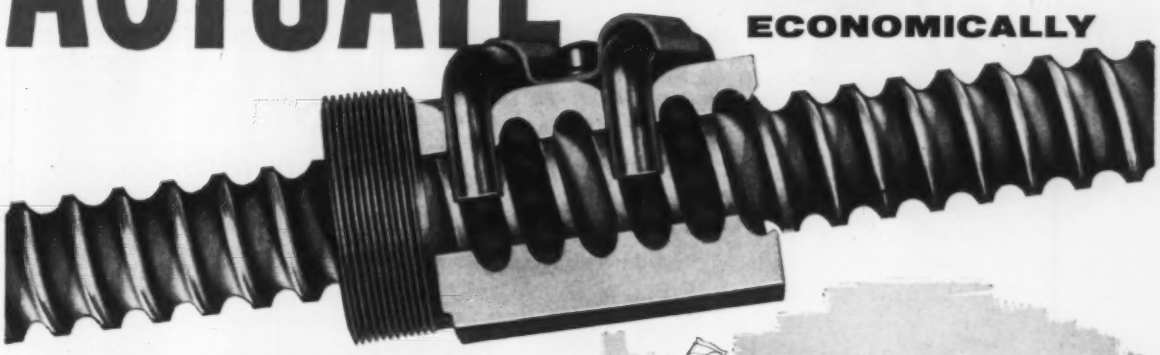
SEND FOR CATALOGS

Catalogs, price lists and selection tables of gearmotor speed reducers and motoreducers are available to power transmission engineers. Please request on company Letterhead —we'll mail your copy at once.

Circle 502 on Page 19

ACTUATE

MORE QUICKLY . . .
EFFICIENTLY . . .
ECONOMICALLY



ROLLED THREAD
SAGINAW b/b SCREWS
Give Volume Products New Production and Sales Advantages

Because Saginaw employs an important anti-friction principle—steel balls recirculating in closed-circuit raceways—b/b Screws provide efficiencies of over 90%—perform up to *5 times* better than acme screws. Saginaw b/b Screws require far less torque—save up to 85% on operating power or manual effort. They are smaller and lighter than comparable units—permit smaller motors and gear boxes; often eliminate clumsy auxiliary parts. May be used with flange, trunnion, worm wheel or torque tube adaptors. Smooth, almost frictionless operation assures long, trouble-free performance, even in extreme temperatures and with lack of lubrication.

"OFF-THE-SHELF" STOCK REDUCES COST

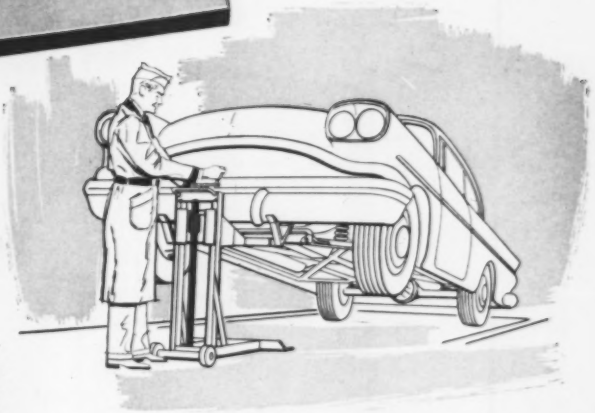
Saginaw b/b Screws are the only kind stocked in seven commercial rolled thread sizes, in 6-inch increments of length (up to 4 ft. for .375" BCD, 8 ft. for .631" BCD, and 11 ft. for all larger sizes.) Ball Circle Diameters are as follows:

.375" .631" 1.000" 1.171" 1.500" 2.250" 3.000"

MANY TYPICAL APPLICATIONS

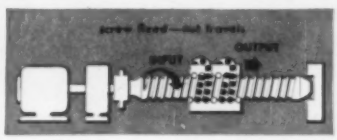
Saginaw b/b Screw standard assemblies have been successfully applied to such products as bumper jacks, automatic garage doors, automobile seat adjusters and window lifts, beauty parlor chairs, hospital beds, and circuit breakers. They are also being used in heavy industrial equipment like die table positioners, drill presses, lift trucks and welding machines.

FREE ENGINEERING HELP FOR YOUR SPECIAL APPLICATION



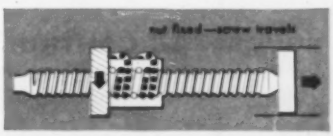
With a Saginaw b/b Rolled Thread Screw in the jack, just a spin of the handle raises a heavy car easily . . . smoothly . . . safely.

HOW THE WORLD'S MOST EFFICIENT ROTO-LINEAR DEVICE WORKS



NUT TRAVELS: When rotary motion is applied to the screw, the b/b nut glides along the axis of the screw on rolling steel balls, converting rotary force and motion to linear force and motion with 4/5 less torque.

SCREW TRAVELS: When rotary motion is applied to the b/b nut, the screw glides along its longitudinal axis on rolling steel balls, converting rotary force and motion to linear force and motion with new efficiency.



LET SAGINAW'S EXPERIENCED ENGINEERS HELP SOLVE YOUR SPECIAL APPLICATION PROBLEMS . JUST WRITE OR PHONE US—NO OBLIGATION

Saginaw ball bearing Screw

SAGINAW STEERING GEAR DIVISION • GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN

NEW from DENISON

4-WAY VALVE

Pilot-operated, solenoid-controlled for hydraulic systems up to 3000 psi

SHOCKLESS CONTROL is assured with Denison's new line of 4-Way Valves for any directional control requirement.

Designed to provide directional control of oil flow up to 30 gpm—pressures up to 3000 psi, and all porting and positioning combinations—these new valves offer exceptional design versatility to Hydraulic Engineers because:

1. They meet all JIC requirements.
2. Over-all length is shorter than any other comparable valve.
3. Shortest solenoid power stroke increases operative force.
4. Special built-in check provides pilot pressure without adding another valve to the system.
5. No bulky, external chains to catch on equipment or personnel. Rugged, drawn-steel solenoid covers are secured to body with internal retaining cords.
6. Oil-enclosed solenoids are available.
7. Direct current operation also available.
8. Interchangeable parts simplify service and model changes in the field.

DESIGNERS ENGINEERS!

Send for Bulletins VD-7 and VD-8

for full details write

DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1240 Dublin Road • Columbus 16, Ohio

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DENISON HydrOILics

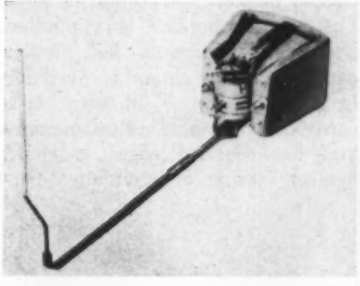
spring rate. Used for equalizers, radius rods, engine fuel controls, torque restrainers, pylon supports, and thrust and drag load links, rod ends are available in a large range of sizes. **Lord Mfg. Co.**, 1635 W. 12th St., Erie, Pa. F

Circle 687 on Page 19

Moving-Coil Mechanism

has gravity-compensated, flexure-pivot bearing system

New moving-coil mechanism, designated MEP-10, is intended for use in high-performance aircraft instruments. Unit incorporates a gravity-compensated flexure pivot which provides a frictionless bearing and infinite resolution without axial or radial play. Pivot members, arranged in pairs, serve as calibrated springs, provide restoring torque, and counteract and elim-



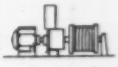
inate forces introduced by gravity for any orientation of the moving-coil system. **Marion Electrical Instrument Co.**, Grenier Field, Manchester, N. H. B

Circle 688 on Page 19

Electrical Connector

uses ball-and-socket for contact pins

New plug-in connector makes or breaks any number of electrical circuits simultaneously. Self-aligning, unit employs a ball-and-socket principle for its contact pins. Two ball-type pins are connected by a split sleeve held together by two garter springs. Action of ball-contacts in sleeve is that of a universal joint, therefore, pin location does not have to be held to close tolerance. This allows for further misalignment due to shock, vibration, and temperature changes. Connectors are for 50-amp capacity at 30 C rise and resist vibration of 45 g in three axes

on direct-connected motor powered equipment with high starting torque, the motor must be sized B I G for starting instead of small for running. this makes you buy more motor than you really need or use a wound-rotor type more expensive than you want. a better way is to use the small motor and drive through a National Torque Converter  this "tailors" the power to the need, multiplies maximum motor torque up to three times X 3 for starting, boosts torque instantly when overloads occur, bans motor stall and increases equipment life.

National Torque Converters help smaller motors do a bigger job

Heavy, electric-powered equipment operating on an intermittent, on-off-on-off work cycle gives motor drives a mighty tough time—unless it drives through a National Torque Converter. The converter multiplies starting torque so that a standard motor, sized to take care of the equipment's *running* needs, can supply the extra push needed for starting. Added loads imposed by multiple operations are smoothly cushioned. Shocks and strains, so hard on equipment, are absorbed. The extra cost of a special motor, and the extra day-to-day expense of operating an over-sized power plant are both eliminated.

If you are concerned with manufacture or operation of any heavy equipment where electric drives of from 100

National Torque Converters are manufactured with or without integral cooling systems.

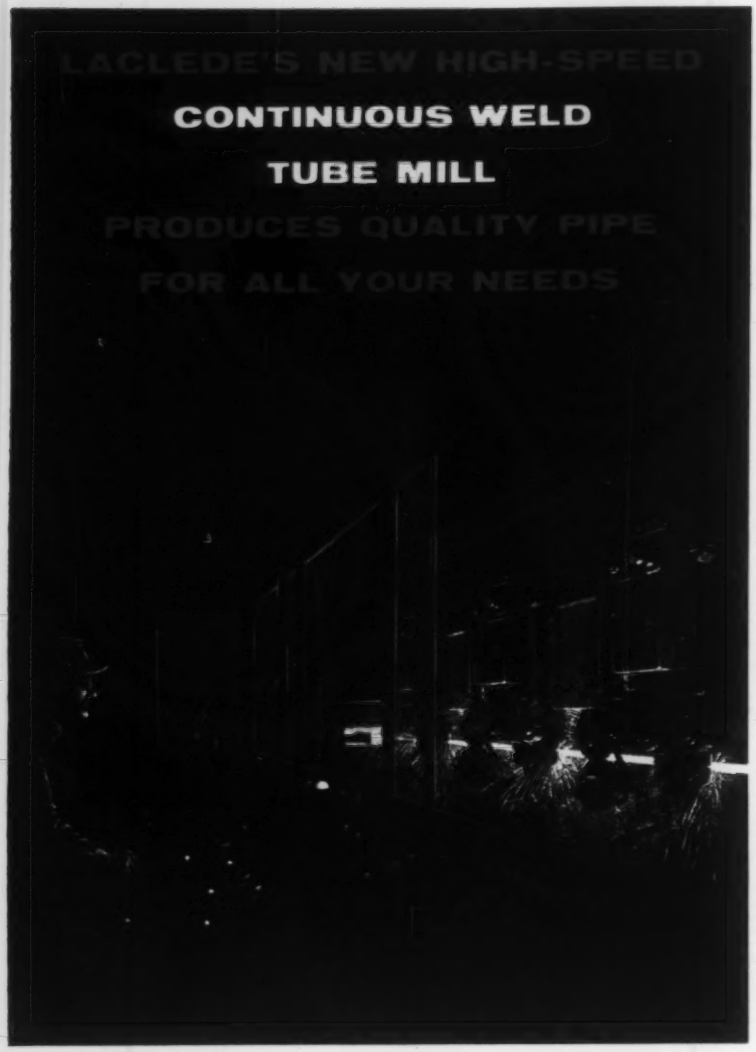
to 1000 hp are used, the National line of Torque Converters will provide you with a unit precisely "mated" to load and application. For details write:

THE NATIONAL SUPPLY COMPANY

INDUSTRIAL PRODUCTS DIVISION

Two Gateway Center, Pittsburgh 22, Pa.

Pace-setters in the progress of industrial power transmission



Continuous weld pipe, in sizes ½ inch through 4 inch and in lengths up to 60 feet, is now available from Laclede's new high-speed continuous weld tube mill.

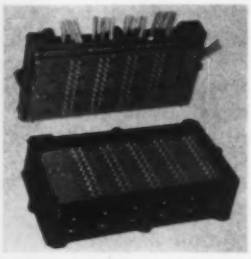
Made with uniform physical characteristics, pipe from Laclede's new mill is quality controlled . . . every step of the way . . . assuring quality tubing at its best.

LACLEDE STEEL COMPANY

Producers of Quality Steel for Construction and Industry

SAINT LOUIS 1, MISSOURI

Circle 506 on Page 19



over 2000 cycles. Temperature range is −65 to 250 F. **Cole Electric Co.**, 8439 Steller Drive, Culver City, Calif. L

Circle 689 on Page 19

Harness Clamp

is opened or closed in a quarter turn

Quick-operating 7C harness clamp can be permanently mounted by means of a rivet or a bolt, and is opened or closed in a quarter turn. Designed for holding wire bundles, hose, cables, conduit, and similar equipment, the clamp is available in ⅜, ½, ⅝, and ¾-in. sizes. It is corrosion-resistant stainless material and has rounded edges to guard against cutting or scratching. Fas-

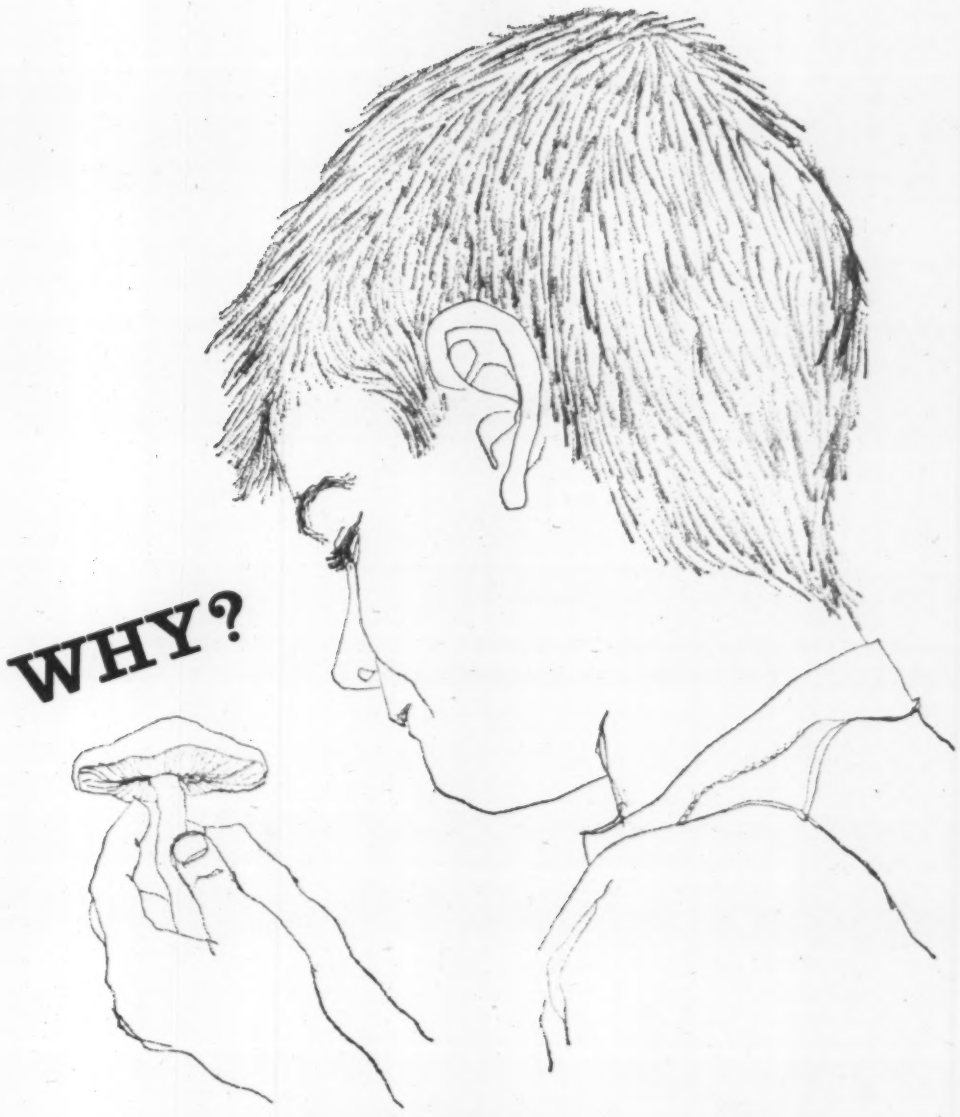
tening is accomplished with a quarter-turn fastener to provide quick operation and positive resistance to shock and vibration. **Camloc Fastener Corp.**, 37 Spring Valley Rd., Paramus, N. J. D

Circle 690 on Page 19

AC Motors

are built to NEMA rerate specifications

New ac motors, built to NEMA rerate specifications, are lighter in weight, and occupy less space than standard units, but provide the same output. For example, a standard frame, 1-hp, 1800-rpm squirrel-cage motor weighs about 74 lb, while rerated motor with the same



YESTERDAY it wasn't there. Today, he picks it up and wonders: *why did it grow like that?* The miracle of growth! Whether it's a "toadstool" that springs up overnight or a cancer cell that suddenly comes into being, we've a lot to learn about the whole beautiful process of orderly growth . . . and the dreadful, senseless growth that is cancer.

The cancer puzzle is tied up in growth —growth of body cells smaller than the periods on this page.

Scientists, working under grants from the American Cancer Society, are ceaselessly studying cells—normal and cancer cells. And they too are asking: *Why?*

Why do cells suddenly change from normal growth to uncontrolled, disorderly growth? This question can be answered only by the most probing, painstaking and costly research.

Your contributions to the American Cancer Society will support hundreds of scientific studies necessary to save lives today and tomorrow.

Remember: Cancer can strike anyone. But you can strike back *hard* with your dollars. Send your gift to CANCER in care of your local post office.

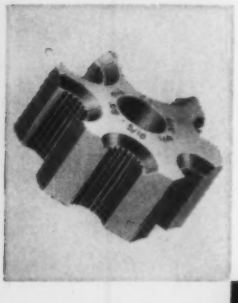
AMERICAN CANCER SOCIETY

GIVING YOU

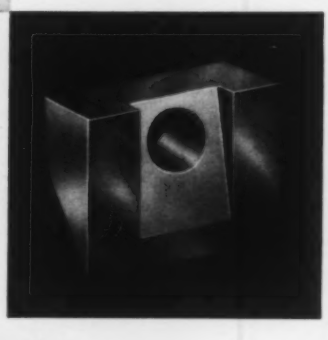
...the best and most modern!

Bunting today covers a new area in the engineering and manufacture of bearings and machine parts. To the traditional line of Bunting Cast Bronze Bearings and parts is added up-to-date, soundly established facilities for engineering and manufacturing bearings and parts made of Sintered Powdered Metals.

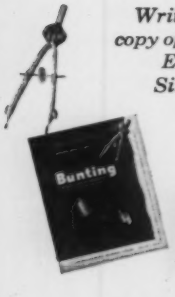
In an entirely new plant with the very latest equipment, Bunting now attains the position in the Sintered Powdered Metals field which it has long held in the field of Cast Bronze Bearings.



A competent group of Bunting Sales Engineers in the field and a fully staffed Product Engineering Department put at your command, comprehensive data and facts based on wide experience in the designing and use of Cast Bronze and Sintered Powdered Metal Bearings and parts.



Write for catalogs and your copy of the new 24 page Bunting Engineering handbook of Sintered Powdered products and their composition, manufacture and application.



Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

characteristics weighs about 65 lb. Temperature rise remains at 40 deg. Rerated open dripproof motors are presently available. **Brook Motor Corp.**, 3553 W. Peterson Ave., Chicago 45, Ill. I

Circle 691 on Page 19

Tantalum Capacitors

solid electrolyte units are rated to 50 v dc

New solid electrolyte Tantalytic capacitors, suitable for use from −80 to 85 C, show excellent capacitance stability over a wide temperature range. With ratings to 4 mfd, 50 v, capacitors are suitable for use in miniaturized, transistorized circuits. Sizes range from 0.250 to

0.438 in. long by 0.125 or 0.175 in. in diameter. Units are hermetically sealed. **General Electric Co.**, 1 River Rd., Schenectady 5, N. Y. C

Circle 692 on Page 19

Teflon Terminals

subminiature units in many new constructions

New standoffs, feed-throughs, jacks, plugs, reverse, and double constructions have been added to a line of subminiature Teflon terminals, designated Trinseel. Other new types include test-point jacks with beryllium-copper contacts, and special fabrications with unusual pin forms and sizes. Terminals are especially suited for electronics assemblies because they are quickly installed in a punched or drilled chassis hole. Fluorocarbon insulating body re-

Circle 508 on Page 19

What shape is a quality fastener?

Here is a handful of ELASTIC STOP® nuts. Each has ESNA's familiar red locking collar . . . is self-locking and vibration-proof. Each is a readily assembled, one-piece unit. Each provides positive protection against thread corrosion . . . prevents liquid seepage along bolts. Each is made from the finest of raw materials. Each is exactly controlled as to finished dimensions, class of thread fit and finish. Each is now in use on critical applications, with a record for uniform high quality that is unmatched.

Most of them are standard parts. Some originated as the result of a specific request for ESNA's help with an important fastening problem.

Isn't it logical to call on us with your next fastening problem?

ELASTIC STOP NUT CORPORATION OF AMERICA

ESNA TRADE MARK

ROLLPIN TRADEMARK

Elastic Stop Nut Corporation of America
Dept. N62-64. 2330 Vauxhall Road, Union, New Jersey

Please send the following free fastening information:

☐ ELASTIC STOP nut bulletin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

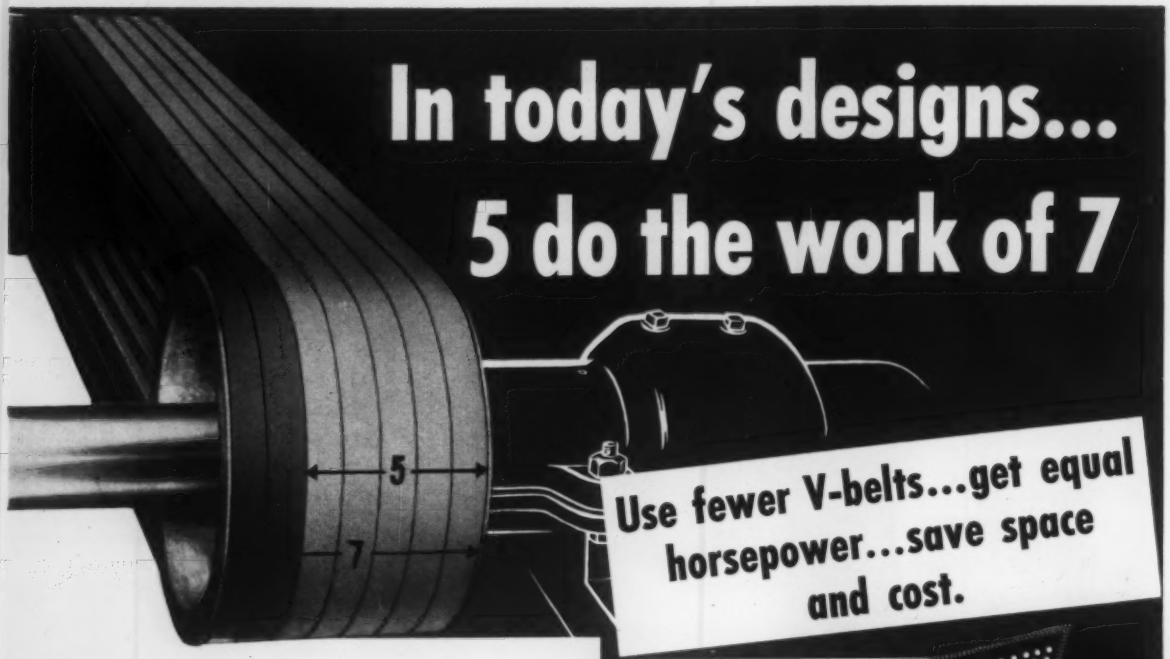
Name_____ Title_____

Firm_____

Street_____

City_____ Zone_____ State_____

In today's designs... 5 do the work of 7



Use fewer V-belts...get equal horsepower...save space and cost.

With 40% more horsepower, 5 Gates Super Vulco Ropes do the work of 7 standard V-belts... improve drive design. That's why—

A Super Vulco Rope Drive delivers more horsepower per dollar invested than any standard V-belt drive.

Comprehensive drive data is available to you quickly. Just call your nearby Gates distributor for a Gates V-Belt specialist. Stocks carried in industrial centers throughout the world.

Gates Distributors are in the Yellow Pages

The Gates Rubber Company
Denver, Colorado
World's Largest Maker of V-Belts

Gates® The Mark of Specialized Research

No other V-Belt has ALL these advantages

1. Flex-Weave Cover (U.S. Pat. 2519590)
A Gates exclusive: provides greater flexibility with far less stress on fabric. Cover wears longer... increases belt life... more power available to driven machine.

2. Concave Sidewalls (U.S. Pat. 1813698)
Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1A). Uniform contact means less wear on sides of belt... far longer belt life.

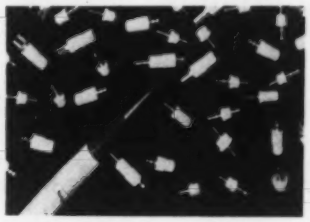
3. Tough, resilient Tensile Cords
Super-strong resilient tensile cords provide 40% greater horsepower capacity ... easily absorb heavy shock loads... reduce number of belts required... save weight and space.

4. High Electrical Conductivity
Built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

5. Oil, Heat, Weather Resistant
Special rubber compounds make Super Vulco Ropes highly resistant to heat, oil, and prolonged exposure to weather.

TPA 331

Gates Super VULCO ROPE Drives



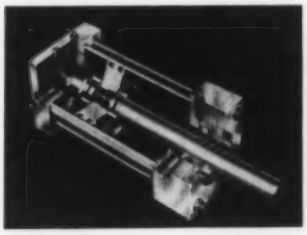
tains terminal permanently under vibration and shock. **Tri-Point Plastics Inc.**, 175-177 I. U. Willets Rd., Albertson, L. I., N. Y. D

Circle 693 on Page 19

Air Cylinders

for 150-psi air and 500-psi oil pressure

Squaremaster improved air-cylinder line consists of 23 different models, each in ten bore diameters, for air pressures to 150 psi and oil pressures to 500 psi. Cylinders are available in seven standard mountings—extended tie rod, angle foot, lug foot, trunnion, blind-end flange, rod-end flange, and clevis. Cushioning can be provided in all cylinders, the degree of cushioning



being varied by adjusting screws. Mounting dimensions are identical for cushioned and noncushioned units. **Rivett Inc.**, Brighton 35, Boston, Mass. B

Circle 694 on Page 19

Limit Switches

two-circuit units have high electrical rating

Two small-size, two-circuit limit switches are completely sealed to protect moving parts from dust and moisture. Switch designated 1LS10 (right) has a rod actuator and is field adjustable through 360 deg, locking positively in any position. It can also be adjusted to operate in either or both directions. Switch is used in applications requiring low force and special lever forms. Second switch, designated 8LS1 (left), has

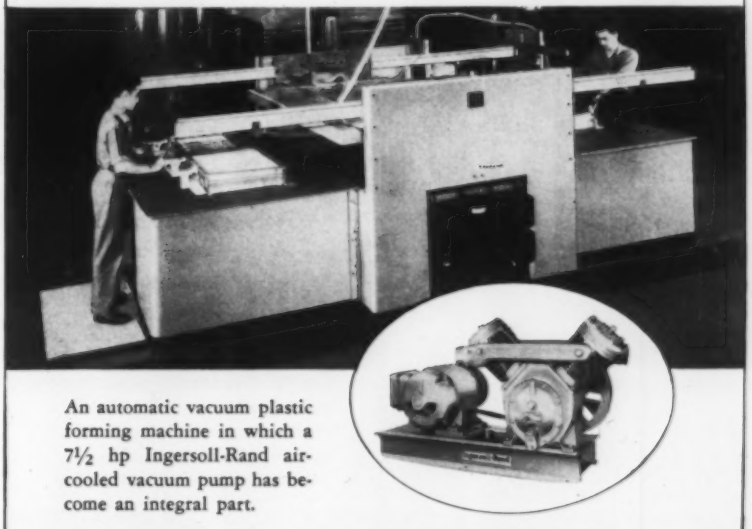
"APPLICATION ENGINEERING"

. . . is part of our business

If your problem is incorporating a compressed air or vacuum system in the machinery you are designing, Ingersoll-Rand can be of help.

Ingersoll-Rand, the world's largest manufacturer of compressors, has a complete line of small air-cooled compressors and vacuum pumps that range from ½ through 20 horsepower and are ideally suited for building into your product.

Why not call in an Ingersoll-Rand specialist, and let him help you with your compressed air or vacuum problem. Call your nearest I-R branch office or write for complete literature.

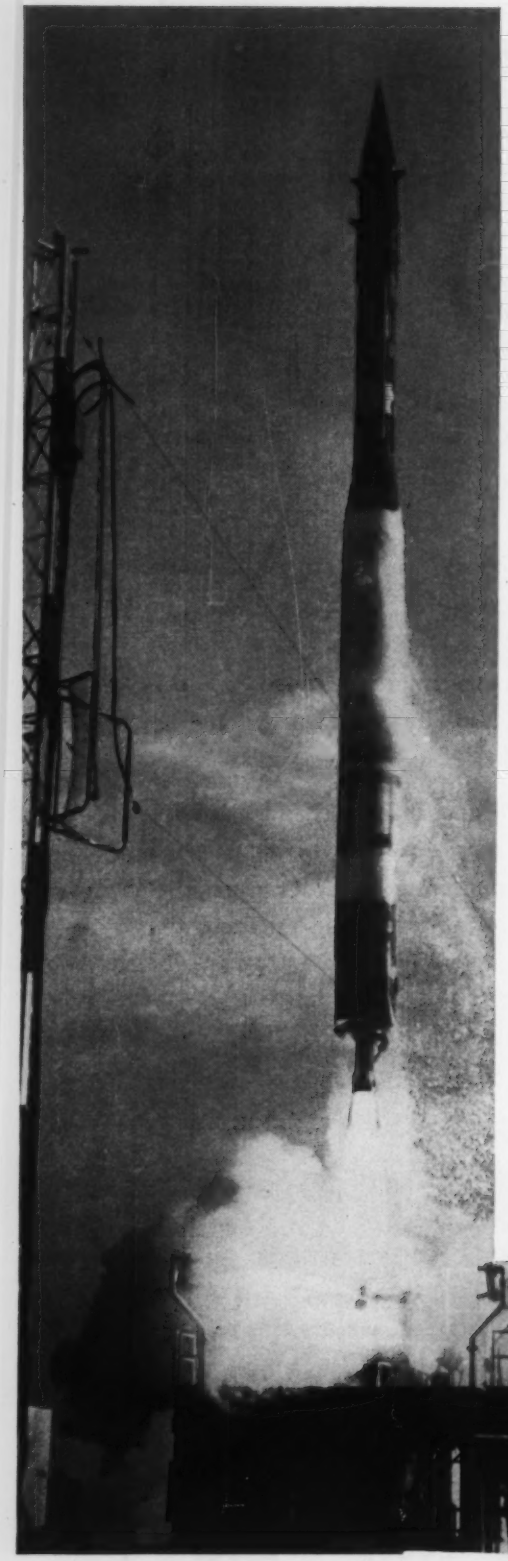


An automatic vacuum plastic forming machine in which a 7½ hp Ingersoll-Rand air-cooled vacuum pump has become an integral part.

Ingersoll-Rand

3-809 11 Broadway, New York 4, N.Y.

Circle 511 on Page 19



B.F.Goodrich

B.F.Goodrich Rivnuts® guard control cables on Vanguard rocket

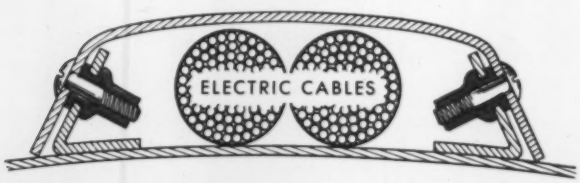
They couldn't put the electrical control cables *inside* the second stage of the Martin Vanguard rocket because of the integral fuel tanks. So they ran the cables *outside*—and protected them with a special cover.

To fasten this cover to the rocket, project engineers chose B.F.Goodrich Rivnuts—for two reasons.

First, B. F. Goodrich Rivnuts provide a vibration-resistant nutplate that won't jar loose in flight. The cover always stays solidly in place. Second, with Rivnuts the cover can be removed and replaced as many times as necessary during pre-flight preparations.

B. F. Goodrich Rivnuts, the only one-piece blind fasteners with threads, can be installed by one person—from one side of the work—in seconds. Upsetting is easy. Just thread the Rivnut on the header tool, insert in the work, and upset. In every kind of operation Rivnuts are used to speed assembly—simplify fastening jobs in thin sheet metal, plastic, rubber and wood.

Find out how B. F. Goodrich Rivnuts can solve fastening problems in your orbit. Send for the free Rivnut Demonstrator that shows—with motion—how Rivnuts can be used to fasten *to* and *with*. Write: B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Dept. MD-68, Akron, Ohio.



B.F.Goodrich aviation products

a coil-spring actuator that permits operation from any direction except direct pull. Easily operated by large, irregularly shaped objects, this type is suited to conveyor and counting applications. Basic switches are rated at 10 amp, 120, 240, or

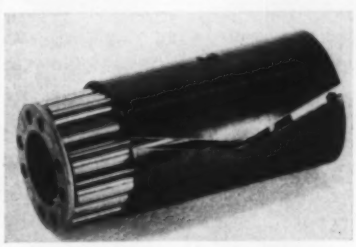
480 v ac; ½ hp, 120 v ac; 1 hp, 240 v ac; 0.8 amp, 115 v dc; 0.4 amp, 230 v dc; 0.1 amp, 550 v dc; pilot-duty rating, 600 v ac maximum. **Micro Switch, Div., Minneapolis-Honeywell Regulator Co.**, Freeport, Ill. K

Circle 695 on Page 19

Roller Bearings

in hardened and ground alloy-steel types

Line of roller bearings in 90,000 series now includes hardened and ground alloy-steel types in addition to the unhardened type. All bearings are furnished with or without



split outer race. **Corlett-Turner Co.**, 9145 King St., Franklin Park, Ill. I

Circle 696 on Page 19

High-Temperature Alloy

for highly stressed parts used at temperatures to 1200 F

Improved high-temperature alloy, known as Lapelloy C, is used for highly stressed parts involving service temperatures to 1200 F. High mechanical properties can be developed by heat treatment. Metal has good resistance to scaling and oxidation for continuous service to 1400

in this data processing equipment . . .

a SPENCER Vacuum Unit

Solved TWO design problems!

Uniservo for Remington Rand Univac® II system.

How to maintain proper tension on the metal or plastic tape was one problem. How to cool the tubes was another.

A ⅓ H.P. SPENCER vacuum unit solved *both* design problems. Intake side is utilized to keep the tape taut . . . exhaust is used to ventilate the cabinet and keep tubes cool.

Perhaps vacuum can help solve *your* design problem. Why not check with SPENCER, manufacturers of a complete line of vacuum and blower units . . . for standard or special requirements.

Two Catalogs to Aid the Designer

"132 UNUSUAL USES OF SPENCER VACUUM"
Bulletin 144 illustrates and describes how Spencer Vacuum is used in industries from A to Z.

"TURBO DATA BOOK"
Supplies application data on Spencer Blowers. Request Bulletin 107-C.

STANDARD CAPACITIES
of Spencer Vacuum Producers
2 through 400 H.P.
Up to 12" Mercury Vacuum
Volumes up to 17,000 C.F.M.

The SPENCER TURBINE COMPANY
HARTFORD 6, CONNECTICUT

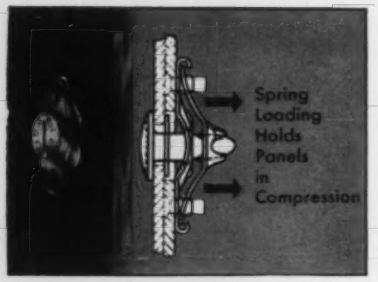
Circle 513 on Page 19

Quick-Opening Fasteners

Selecting Small Fastenings for Metal Closures

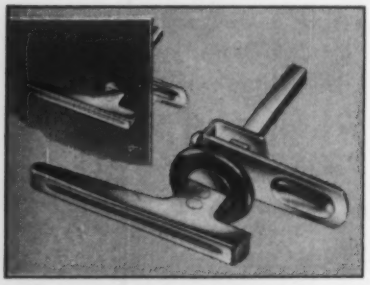
*"Use captive fasteners wherever feasible . . . Avoid the use of loose washers and loose nuts . . . Fasteners on equipment covers should be operable either with no tools or with standard hand tools"**

(John D. Folley, Jr. & James W. Altman, Research Scientists, American Institute for Research)



Quarter-Turn Fastener

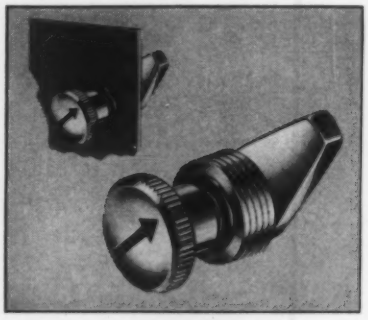
Lion Fasteners open and close with a ¼ turn, hold sheets tightly under the compression of a rugged spring. Quickly operated and fully retained in the outer panel, they are approved under U. S. Government military specifications. Stud and receptacle float for easy alignment and simplified hole preparation. Flush, oval, wing, knurled, ring, and key head styles available. Sizes—No. 2, No. 5, and High Strength for extra heavy duty



Cabinet Latch

Just drill a hole, push the fastener stem through, and slide the special push-on clip into place. No welds, screws, bolts or rivets: the fastener is permanently installed in seconds!

Adjustable to any grip length or panel thickness, the pawl is fixed in place by a single set screw. The fastener's brightly finished knob is set off by a plated washer. Also furnished with screwdriver operated flush head.

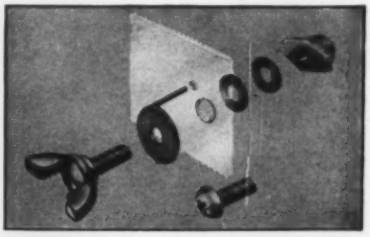


Spring Tension Latch

For fastening slide-out drawers and hinged panels the Southco Arrowhead Latch is recommended. It locks or opens with a quarter turn yet occupies less than ½" inside space.

Doors are held under spring tension—a push against the arrowhead knob relaxes this tension, allows operation with fingertip ease. Drill a single hole for installation—no fastening to the door is necessary No striker plate is needed.

Pawl stop is eliminated—arrowhead shows at a glance exact position of pawl.



Adjustable Panel Latch

Small doors and panels can be fastened with greatest speed and lowest cost with the Southco Adjustable Latch.

The entire fastener is quickly installed through two holes punched in the door; no bolts or rivets are needed.

It operates with a quarter turn, requires no striker plate. An extra twist after the nylon pawl is engaged pulls up the door to form a seal and eliminate vibration.

Available with wing, knurled, or Phillips head.

Free Fastener Handbook

Send for your free copy of Fastener Handbook No. 8, just released. Gives complete engineering data on these and many other special fasteners. Forty-eight pages, in two colors.

Write on your letterhead to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

SOUTHCO FASTENERS

LION

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* *Quotation from "Designing Electronic Equipment for Maintainability"; Machine Design, July 12, 1956.*

F. Alloy offers best corrosion resistance when in hardened and tempered condition. It is used for compressor wheels, turbine shafts, compressor buckets, blades, and bolts. Lapelloy C is readily machinable. In the annealed condition it is comparable to Type 420 stainless steel. It is available in billets, hot-rolled and cold-finished bars, wire, cold-rolled strip, and special shapes. **Carpenter Steel Co.**, Reading, Pa. C

Circle 697 on Page 19

Miniature-Tube Relay

has excellent shock and vibration resistance

Redesigned PW miniature-tube relay operates on 40 mw under shock of 30 g and vibration of 10 g to 500 cps. Unit operates on current to 6 amp and voltages to 115 v dc. Relay is supplied with seven-pin

miniature plug-in headers for tube-socket or printed-circuit mounting, or with pierced solder lugs and brackets for flange mounting above or below chassis. Balanced armature permits mounting in any position without significantly affecting shock and vibration resistance. **Technical Information Dept., Potter & Brumfield Inc.**, Princeton, Ind. J

Circle 698 on Page 19

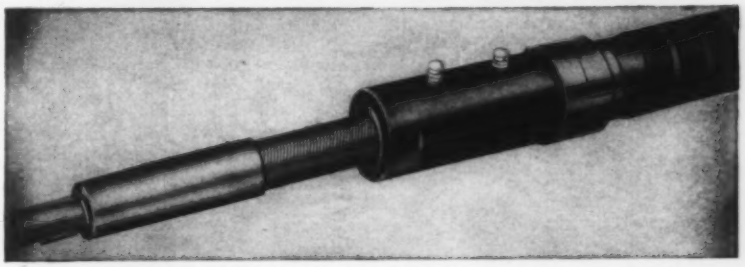
Drives and Couplings

are available in fractional-horsepower sizes

New fractional-horsepower Flexidyne dry-fluid drives and couplings, identified as 5D (left) and 5C (right), are designed for ¼, ⅓, ½, and ¾-hp motors at 1750 rpm. They are for use with light machines subject to jam-ups, and enable small motors to handle heavy starting loads. Drives and couplings provide cushioned starting, 100

(Advertisement)

HOW TO SELECT FLEXIBLE SHAFTING FOR POWER DRIVE APPLICATIONS



1¼-inch STOW Power Drive flexible shaft with core assembly pulled out of casing.

For Power Drive applications, the following factors must be considered:

1. Torque (Lb. In.) to be transmitted. (The starting torque should be used in making selections.)

2. Operating Speeds (RPM) — If the maximum speed is higher than the rated speed, torque ratings in the table below do not apply. To find the torque capacity for flexible shafts operating at speeds higher than the rated speeds, multiply the maximum dynamic torque capacity by the rated speed, and then divide by the operating speed. (See example.)

3. Operating Radius—In making the selection from the table below, the radius of the smallest bend in the flexible shaft should be used.

Ratings — The ratings for flexible shafts shown in the table below apply under the following conditions:

1. When the flexible shaft is adequately supported by clamps along its length. (For unsupported shafts, multiply the calculated torque by a safety factor of 1.6—see example below.)

2. When the flexible shaft is operated in the wind-up direction, which tends to tighten the outer layer of wires. (Flexible shafts operated in the unwind direction will transmit only about 60% of the rated torque.)

3. When the flexible shaft is in continuous operation. Note: **the ratings are based on temperature rise. When the operation is intermittent, the ratings in the table may be exceeded. Consult Stow engineers for specific recommendations.**

RATED SPEED R.P.M.	MAXIMUM DYNAMIC TORQUE CAPACITY (LB. IN.) STRAIGHT AND CURVED SHAFTS RADIUS OF CURVATURE IN INCHES									Wgt./ C. Ft.	Core Dia.	Core No. and Type	Shaft Size
	50 to Strgt.	25	20	15	12	10	8	6	5				
4,500	2.4	2.2	2.0	2.0	1.92	1.9	1.7	1.5	1.25	3.0	.124/ 128	2049 MH	13
3,800	7 0	6.4	6.0	5.8	5.4	5.0	4.6	3.6	2.0	4.5	.148/.152	2081 MH	15
2,900	9.4	8.6	8.0	7 6	7.0	6.6	6.0	4.8	3.4	7.0	185/.189	5108 MH	19
2,500	22.0	20.0	18.8	17.6	16.0	15.0	12.6	10.8	9.0	12.5	.247/.252	8924 MH	25
1,800	30.0	28.0	26.4	25.0	23.0	21.0	18.0	14.0		20.0	.308/.313	8925 MH	31
1,800	33.8	31.5	29.7	28.1	25.9	23.6	20.2	15.8		20 0	.308/.313	8969 T	31
1,800	36.0	33.0	31.6	30.0	28.0	26.0	22.0	18.0	11.0	21.0	.324/.329	2034 A	31
1,500	80.0	66.0	63.0	58.0	51.0	46.0	37.0	22.0		28.5	.368/.374	2035 A	38
1,500	60.0	54.0	50.0	46.0	42.0	38.0	30.0	24.0		29.0	.387/.393	8970 MH	40
1,500	90.0	81.0	75.0	69.0	63.0	57.0	45.0	36.0		29.0	.387/.393	8971 T	40
1,150	136.0	110.0	104.0	94.0	80.0	72.0	56.0			50.5	.497/.503	8999 A	50
1,150	148	124	110	92	72	56				53.5	.505/.511	6940 T	50
900	248	200	176	124	84					78.5	.610/.618	6997 T	63
900	220	204	192	180	152	130				80.5	.630/.638	7731 A	63
750	340	224	156	76						117	.747/.753	2056 T	75
600	760	520	420							205	.998/1.004	2057 T	100
440	1,500	720								343	1.298/1.304	2058 T	125

EXAMPLE — How to use the table:
The problem is to transmit ½ H P at 1700 RPM through an unsupported flexible shaft in a 25" radius, estimated starting torque 150% of normal operating torque.

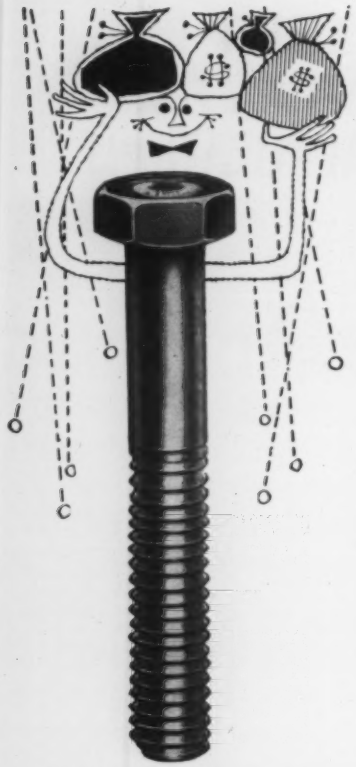
1. Calc. Torque (lb. in.)—
$$\frac{HP \times 63000}{RPM} = \frac{.5 \times 63000}{1700} = 18.5$$
2. Correction factor for starting torque 1.5 x 18.5 = 27.75
3. Correction factor for unsupported shaft 27.75 x 1.6 = 44.4 lb. in.
4. Refer to Table above. Read downward in column under 25" radius until you find a core having a rating of at least 44.4 lb. in. In this case we find that core no. 8970 is rated 54 lb. in. at 1500 RPM. Since the given speed is 1700 RPM, multiply 54 by 1500 and divide by 1700. 54 × 1500 ÷ 1700 = 47.6 lb. in. (rated torque at 1700 RPM). Therefore, Core No. 8970 is correct.

STOW

For Engineering Bulletin No. 570 and a free torque calculator, write

STOW MANUFACTURING COMPANY

11 Shear Street • Binghamton, New York



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You save dollars when you use Alcoa® Aluminum Fasteners . . . the lowest cost, corrosion-resistant fasteners available. They are a perfect color match for the aluminum products you make, and they insure against both galvanic and atmospheric corrosion. For your requirements, call your nearest Alcoa sales office. Alcoa Aluminum Fasteners . . . in all standard types and sizes . . . are readily available from the complete stocks of your local Alcoa distributor. Look in the Yellow Pages of your telephone directory. Alcoa is a "natural" for specials, too!

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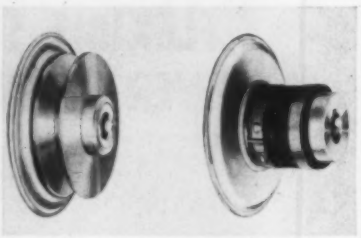
Circle 516 on Page 19



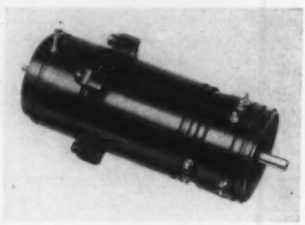
per cent efficiency at full load, and protection against overload. Dodge Mfg. Corp., Mishawaka, Ind. J

Circle 699 on Page 19

Packaged Servomotor Assembly

offers precision performance in modular construction

New packaged servo component, designated Servopot, consists of an integral combination of a two-phase instrument servomotor, gear reduction, slip clutch, and precision potentiometer. Unit has wide application in balancing, positioning, and computing servomechanisms. Addition of an integrally mounted ac tachometer with 0.5 per cent linearity makes component a com-



plete integrating servo. Standard potentiometers feature 0.5 per cent linearity and are available with resistances from 35 to 80,000 ohms. Single, multiturn, and nonlinear models are available. Finderne Plant, Diehl Mfg. Co., Somerville, N. J. B

Circle 700 on Page 19

Heavy-Duty Thermostat

has 30-amp rating

Klixon 20500 Series single-pole, double-throw thermostat has a heavy-duty electrical rating. It is for large-volume applications in clothes dryers, combination washer-dryers, electric heaters, and fan motor controls. Rating is 30 amp noninductive, 120/240 v ac for a standard life of 100,000 cycles on motor loads to ½ hp. Maximum operating temperatures are 300 F for 100,-

SAVE TIME AUTOMATING SMALL PARTS ASSEMBLY OPERATIONS

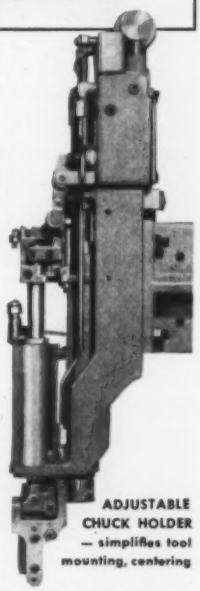
SPECIFY

DIXON

"Auto-Positioner"

FITS IN SMALL SPACE—21" X 3¼" X 5" DEEP

SEE AT DESIGN ENG. SHOW BOOTH-634



ADJUSTABLE CHUCK HOLDER — simplifies tool mounting, centering

- **STANDARD HEAD DESIGN**—Saves engineering time. Easy to apply to variety of jobs. Operates on ordinary 80# air pressure, 110 volts. Has machined T-slot surface, simple adjustments. Tooling, mounting column, feeders, etc., optional.
- **BUILT-IN SENSING**—Acts as automatic inspector, assures quality production. Machine stops if part is missing or malformed.
- **FAST, VERSATILE**—Handles wide range of feedable metal or plastic parts from 1/16" to 3" O.D. at speeds up to 100 cycles per minute. Easy to tool.
- **PRECISION-BUILT**—Sturdy frame, one-piece super-finished piston and rod, cushioned air cylinder, J.I.C. controls.
- **WRITE FOR FULL DATA**—New circular gives complete specifications, shows typical applications.

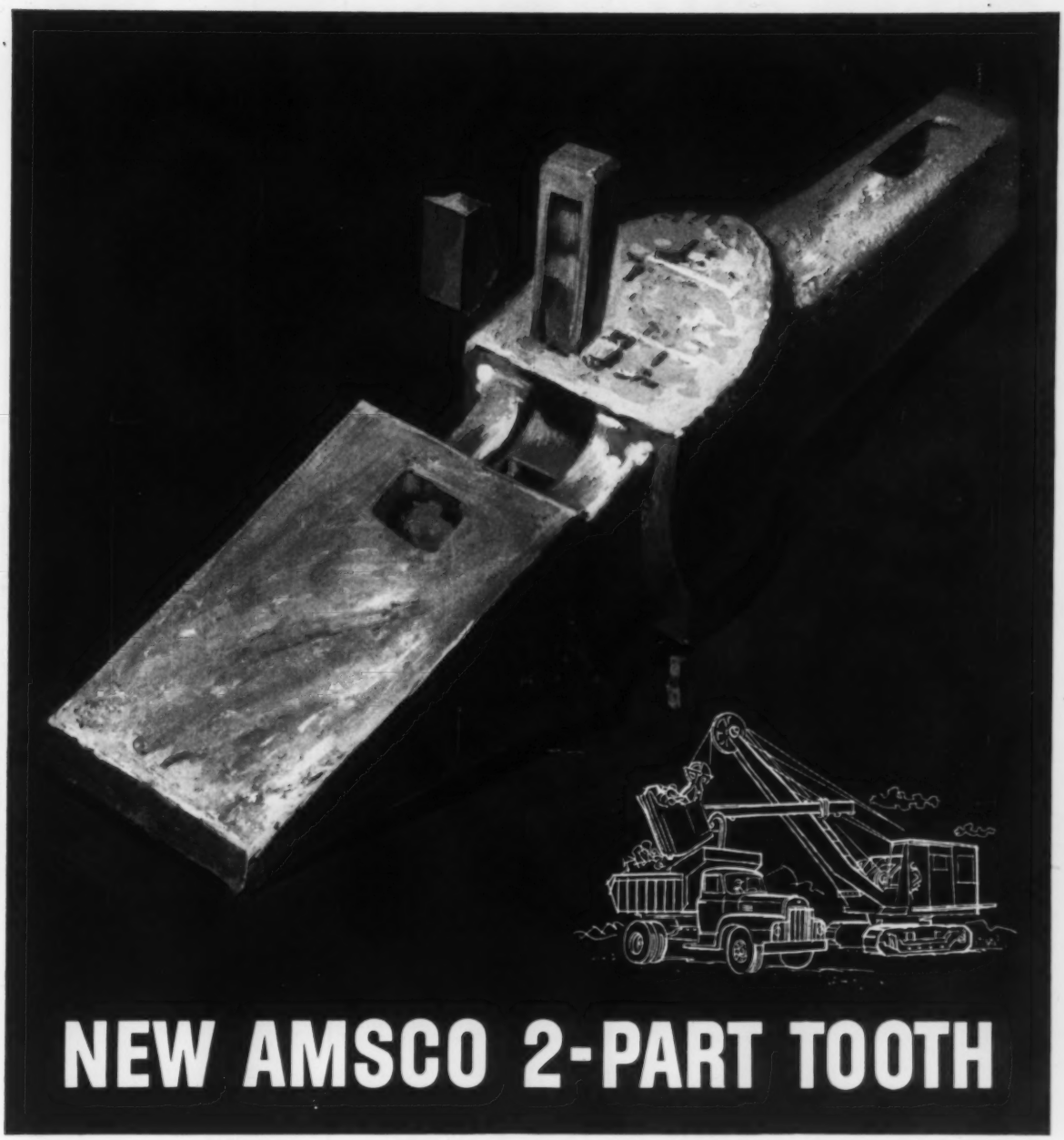
DIXON PARTS ESCAPEMENTS Releases single parts or in multiples at speeds up to 200 per minute. Standard models available for air, solenoid, or mechanical operation.

DIXON

DIXON AUTOMATIC TOOL, Inc.
2310–23 rd AVENUE
ROCKFORD, ILLINOIS

Equipment for Automatic Parts Handling and Assembly

Circle 517 on Page 19



NEW AMSCO 2-PART TOOTH

Special-alloy reversible tips *(easy to reverse)* nearly double tooth digging life...

In quarry work, in cold and hot slag pits... in the roughest of digging tests, these new Amsco® 2-part Simplex teeth have outlasted competitive 2-part teeth more than 2 to 1... at a big saving in tip and adapter replacement time.

You get this longer wearing quality because of the special, rugged alloy used for both tip and adapter. Reversing tips extends digging life even more, yet takes only a few minutes.

Adapters outlast several sets of tips, are equally easy to replace. Pin lock between tip and adapter seats and locks so securely, metal-to-metal, that even side blows can't jar it loose.

We'll be glad to send you a booklet containing reports by Simplex users and describing this new Amsco tooth completely. Write for it today.

AMERICAN Brake Shoe COMPANY

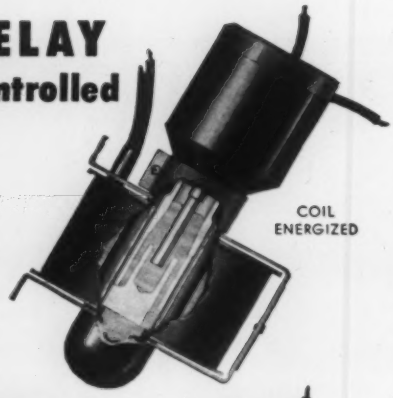
AMSCO

American Manganese Steel Division · Chicago Heights, Illinois

Circle 518 on Page 19

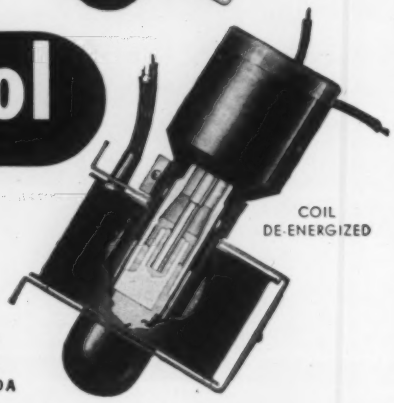
The TIMER RELAY
that handles all controlled timing problems . . .

This steel clad, factory set, tamper proof Durakool timer-relay is practically non-breakable. Operating life multiplied 5 to 6 times by new plunger construction features. Combinations of operate-release time delays from 0.15 sec. to 20 sec.—either normally open or normally closed action.



Durakool
STEEL MERCURY TIMERS

- ★ No false contacts
- ★ Non sticking
- ★ Practically "fail safe"
- ★ Low cost timer

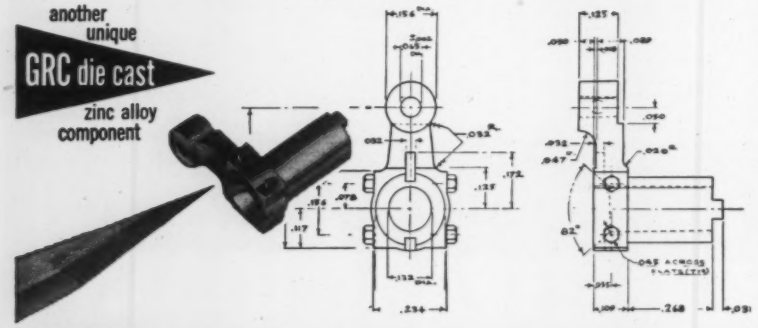


See telephone directory for local distributor, or write.

DURAKOOL, INC.
ELKHART, INDIANA, U. S. A.
700 WESTON RD., TORORTO 9, CANADA

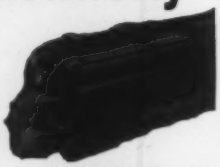
Circle 519 on Page 19

another unique **GRC die cast** zinc alloy component



GRC die casting helps Lionel achieve tiny part authenticity

This intricate toy crank was die cast in zinc alloy by GRC in a single automatic operation. Cost? Little more than $5.00 per thousand in lots of 500,000. Result? Produced quicker and more economically than Lionel could themselves. Less than half an inch overall, it is typical of the many small (maximum is 1¾" ½ oz., no minimum) parts problems solved by GRC's unique techniques. Gries' specialized machines deliver parts ready for use—uniform, accurate, clean —no trimming, no assembly, no scrap loss.



If you have a small parts problem, write, wire or phone for GRC's die casting bulletin or send prints for quotation.

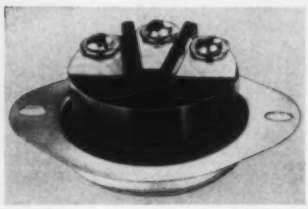
World's Foremost Producer of Small Die Castings

GRIES

GRIES REPRODUCER CORP.
32 Second St., New Rochelle, N. Y., NEw Rochelle 3-8600

Circle 520 on Page 19

000 cycles and 350 F for 6000 cycles. Thermostats are available with thermal actuating disc either enclosed in a stainless-steel cup or exposed. Fixed temperature settings range from −10 to 550 F. Controls can be mounted in any



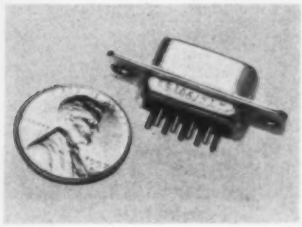
position and are supplied with either an oval or round four-eared flange. **Spencer Thermostat Div., Metals & Controls Corp.**, Attleboro, Mass. B

Circle 701 on Page 19

Subminiature Connectors

for printed-circuit applications

Series D subminiature connectors are available for printed-circuit applications. Units withstand 1-min test voltage (60 cps ac) of 1300 v rms with no evidence of breakdown. Shell material is steel with cadmium-plate finish. Contact material is copper alloy with gold over silver plate, and insulation material is Zytel or diallyl-phthalate. Units



are available with 9, 15, 25, 37, or 50 contacts. **Cannon Electric Co.**, 3208 Humboldt St., Los Angeles 31, Calif. L

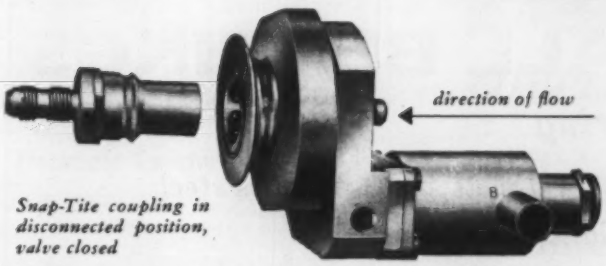
Circle 702 on Page 19

In-Line Filter

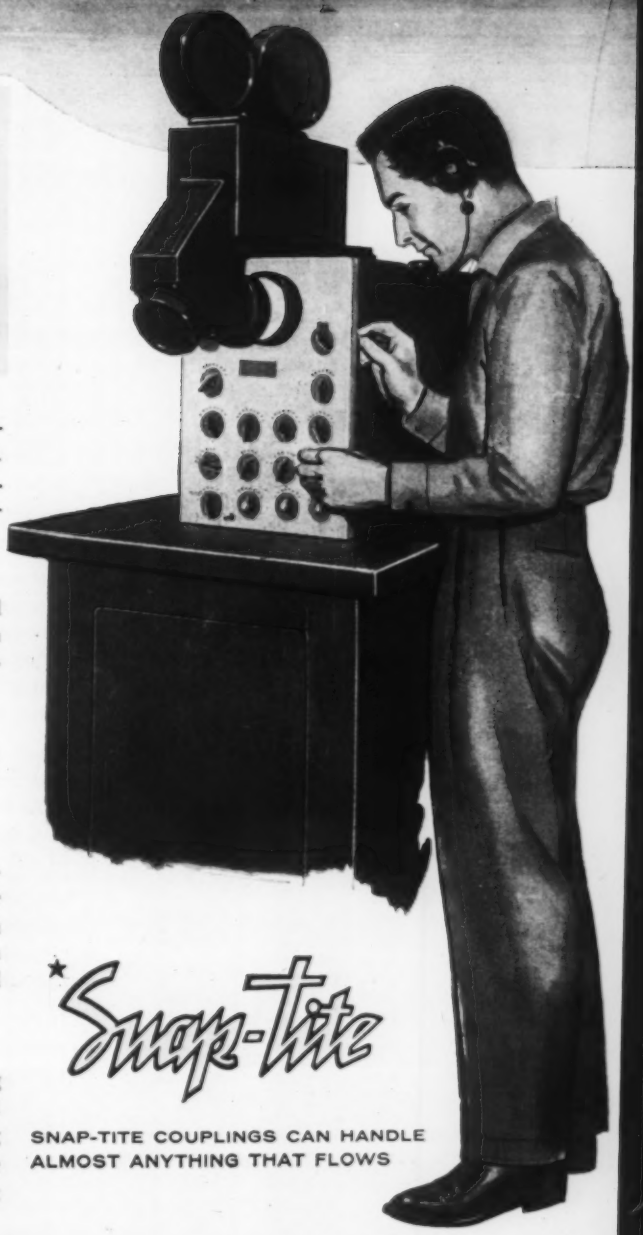
has 10 to 25 gpm hydraulic oil capacity

New filter, designated M-2032-100, is for in-line installation and has hydraulic oil capacity from 10 to 25 gpm at low pressure drop. Filtering media of Monel-wire cloth are

SNAP-TITE REMOTE CONTROL COUPLINGS FOR GUIDED MISSILES



Snap-Tite coupling in disconnected position, valve closed



Here is a specially designed Snap-Tite quick-connect, quick-disconnect coupling, ideal for use in missile-fueling systems. This unit is specifically designed to be manual-connected . . . can also be disconnected manually, or by use of an air-actuated remote control.

NOT A DROP SPILLED!

When the coupling is disconnected, it spills only that small amount of fluid which clings to the metal. The valves in both the coupler and nipple automatically shut off when disconnected, *with no leakage.*

NO AIR INCLUSION!

Coupling operation encloses only a minute amount of air.

MINIMUM PRESSURE DROP!

Smooth, streamlined passages assure maximum flow.

Variations of this coupling, to meet your required specifications, can be furnished with the appropriate seals to handle liquified gasses, exotic fuels, and a large variety of fluids with working pressures up to 3,000 PSI and temperatures from −300°F to +400°F. Units have been designed up to and including 5″ size.

STANDARD COUPLINGS, TOO!

Your coupling needs might not be as critical as the coupling shown here, but you can be sure, when buying standard Snap-Tite couplings, that the same outstanding engineering and manufacturing skills are basic throughout the Snap-Tite line. Write for complete catalog . . . or describe your specific coupling problems. Snap-Tite, Inc., Union City 11, Pa.

★ Snap-tite

SNAP-TITE COUPLINGS CAN HANDLE ALMOST ANYTHING THAT FLOWS

Circle 521 on Page 19

Fafnir presents a **NEW** *series of*

MINIATURE BALL BEARINGS

featuring

1. *Vacuum melt 440C stainless steel*
2. *Balanced design*
3. *Precision tolerances*

Fafnir now offers a series of miniature ball bearings, fabricated entirely of extra clean vacuum melt 440C stainless steel. This steel has a minimum of impurities and eliminates the chances of pits and imperfections in the races.

Because of superior race finish, the ultimate results are supersensitive bearings with low torque values. The balanced construction results from separate retainers for each bearing size. Thus the pitch circle of the balls is centered between the bore and outside diameter.

Made to ABEC-5 tolerances or better, these bearings are engineered for precision instrument applications where performance and long life are vital.

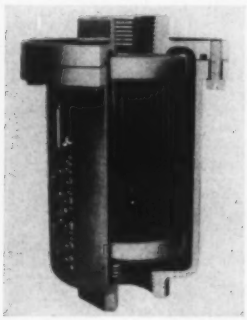
Fafnir's instrument bearing division has been expanded for production of the new miniature series. These bearings are made in the world's cleanest metalworking area, regarded as a model throughout industry.

Investigate this new series of precision miniature bearings. Write for bulletin to The Fafnir Bearing Company, New Britain, Conn.

Fafnir's Precision Miniature Bearings Series currently includes four design variations available in each size.
Open Type • Two Shields
Flanged Type • Flanged Two Shields

FAFNIR
BALL BEARINGS

Circle 522 on Page 19



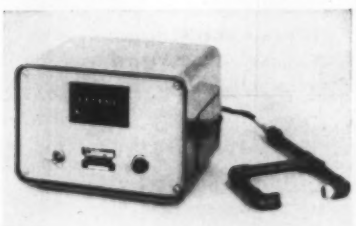
available in mesh sizes from 30 to 100. Cartridge is easily removed for thorough cleaning. No replacement of parts is necessary. Overall length of the unit is 6⅛ in., head diameter, 4¼ in. Openings are 1 in. NPTF at both ends. **Marvel Engineering Co.**, 7227 N. Hamlin Ave., Chicago 45, Ill. J

Circle 703 on Page 19

Electronic Counter

has rated speed of 3000 counts per min

Model C Count-Pak combines a high-speed magnetic counter with a light source and photo cell. Unit has instant reset and rated speed of 3000 counts per min. Photo cell is a small unit that can be made in any configuration to suit application. Cell and light source are unaffected by vibration. Pulses as short as 0.0002 sec actuate the de-



vice. Unit, which incorporates transistors and printed circuits, has pilot light, reset button, and power switch on panel. **Electronic Controls Div., Veeder-Root Inc.**, Hartford 2, Conn. B

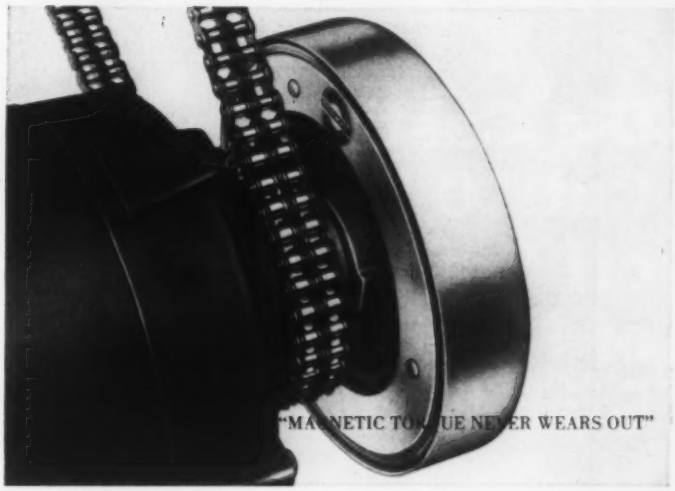
Circle 704 on Page 19

Wound-Rotor Motors

with size reduction up to 59 per cent

Tri-Clad 55 wound-rotor motors, with minimum breakdown torque of 275 per cent, feature up to 59

UNIQUE IN THE FIELD!

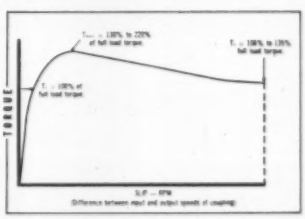


COMPLETE MOTOR DRIVE PROTECTION *with*

Whitney-TORMAG DRIVE

FULL OVERLOAD PROTECTION • CUSHIONED STARTS • HIGH EFFICIENCY • SELF-CONTAINED • TORQUE RATED • SLASHES POWER COSTS • ELIMINATES MAINTENANCE • FOR DIRECT OR POWER TAKE-OFF DRIVE •

Proven throughout industry, the new Whitney-Tormag Drive is a frictionless, permanent magnet-type power transfer unit, which insures against motor burn-outs and costly down time. Now available in 1 H.P. and 2 H.P. (at 1750 RPM input) sizes, ready for quick installation. Additional sizes up to 15 H.P. will follow. Torque ranges—2 ft. lbs. to 45 ft. lbs.



EXCLUSIVE OVERLOAD PROTECTION!

Operating curve illustrates fixed characteristics for optimum performance.

See These Cost Cutting Features

- Runs at full stall (100% slip) without harm to motor or driven element.
- No power loss in fluids, particles or seal friction . . . no pumps, coolers or exciters to cause power drain.
- Meets new N.E.M.A. frame specifications — compact, ready to install in minutes.
- Slip start design allows use of lower H.P. motors—cuts motor, starter and power costs.
- Cushioned starts eliminate shock, reduce maintenance costs.
- Operates from minus 60° F. to 150° F.

Available from stock through your Whitney Chain Distributor.

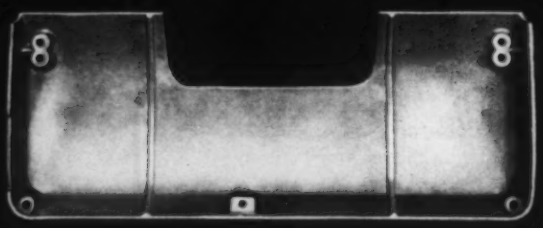
A Product of Whitney CHAIN COMPANY

301C Hamilton Street
Hartford 2, Connecticut

ROLLER CHAIN • CONVEYOR CHAIN • SPROCKETS • FLEXIBLE COUPLINGS • WHITNEY-TORMAG DRIVE

Circle 523 on Page 19

Die Castings Cut 10 Pounds off Frameweight of New Royal Standard



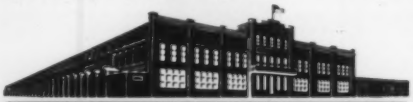
CASE HISTORIES FROM MT. VERNON FILES

"Never before has a standard typewriter featured so many new improvements. From Twin-Pak to Touch, this new Royal Standard opens up a whole new world of breathtaking ease and economy." It is a fine example of beautiful design, excellent engineering and wise choice of materials.

Because of the remarkable strides made by the die casting industry in the production of sound economical aluminum die castings, the major portion of the framework of all the Royal Typewriters are die cast. Through the use of aluminum die castings having cored holes, close tolerances and thin walls ribbed for maximum strength, Royal engineers have reduced the weight of the framework of the Standard model from 15 pounds to approximately 5 pounds . . . an impressive savings of 10 pounds.

All told, the Royal McBee Corporation uses from 2½ to 3 million pounds of aluminum die castings yearly and the end of die casting usage is not in sight. Royal engineers are constantly alert to additional die casting applications because of the tremendous savings in man and machine hours which are achieved through the elimination of costly secondary operations.

A switch to die casting may be *your* next step. It will be well worth your time to bring your product specifications to Mt. Vernon, for ours is a complete, four-fold service of 1. Consultation 2. Die making 3. Die casting 4. and Machining facilities all under one roof occupying 200,000 square feet of space . . . For quick action, contact your nearest sales representative listed below.



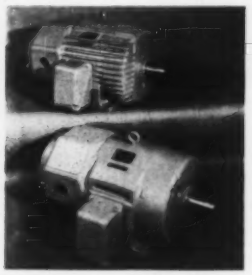
MT. VERNON
DIE CASTING CORP.
STAMFORD, CONNECTICUT

RESEARCH PARTICIPANT

SALES REPRESENTATIVES

STAMFORD, CONN.: Mr. Anker Anderson, Cascade Road
GUILDERLAND, N. Y.: Mr. David H. King, 75 Willow St.
LUTHERVILLE, MD.: Mr. C. McIntosh Gordon, Mays Chapel Rd.
CLEVELAND, OHIO: Mr. Grant Eller, 6 East 194th St.
BROOKLYN, N. Y.: Mr. Robert V. Moore, 2317 Plumb 2nd St.
EAST ORANGE, N. J.: Mr. George E. Hahl, 39 So. Munn Ave.
ROCHESTER, N. Y.: Mr. William Sauers, 101 Briarcliff Rd.
SKANEATELES, N. Y.: Mr. Jerome J. Theobold, 9 E. Genesee St.
VALLEY FORGE, PA.: Mr. G. T. McMaster, P.O. Box 115
BOSTON, MASS.: Mr. James Cleary, 61 Exeter Street

per cent size reduction and 49 per cent weight savings. Motors are available in sizes from 5 to 150 hp. Type MR motors, available in either totally enclosed nonventilated or dripproof enclosures, are suited for applications requiring varying speed and high starting or maximum torque. Type M motors, rated for



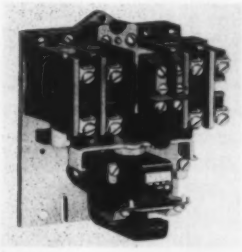
constant or adjustable speed, are available in open dripproof enclosures for application on industrial equipment such as pumps, compressors, and fans. **General Electric Co.**, 1 River Rd., Schenectady 5, N. Y. C

Circle 705 on Page 19

Latch Relays

mechanically held units are available in nine models

Type PML mechanically held latched-in relays are available in nine models with from two to ten poles. Mounting dimensions are standard and parts are interchangeable between magnetic relays and new latch relays. Magnetic and latch relays can be grouped in rows, since latch unit does not require increased vertical height. Poles and latch units are individually removable and replaceable without disturbing other poles or their wiring. Modular construction provides a solid shelf along relay top for flat or bundle wiring, saving vertical height between rows of relays. Latch unit wearing surfaces are nylon on phenolic. Contact carriers are nylon, and link-



Remember!

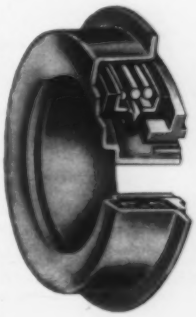
When you specify Mechanical Seals...

JOHN CRANE

can supply the exact seal you require

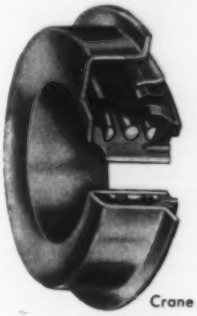
You can achieve the sealing efficiency you want . . . eliminate specification problems . . . work unhampered from drawing board to production—when you work hand-in-hand with "John Crane's" experienced engineering staff and available facilities.

Get quick, finger tip information on "John Crane's" complete line of high production mechanical seals—for every conceivable service—to meet your particular needs. Send now for illustrated technical catalog. It's your's upon request.



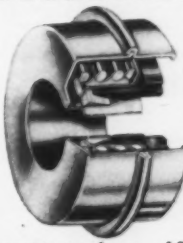
TYPE 6-A

Pressed-in packaged unit recommended for small shafts on hot or cold water, oil, gasoline or soapy liquids . . . pressures to 75 psi . . . temperatures from —65° F. to +220° F. Available in stainless steel or bronze.



TYPE 11-A

Pressed-in packaged unit with spring inside synthetic rubber bellows to protect against corrosion. For hot or cold water, oil, gasoline or soapy liquids . . . pressures to 35 psi . . . temperatures from —65° F. to +212° F.



TYPE 9-A

Packaged unit with wedge sealing ring made of DuPont Teflon. Will handle practically all known industrial chemicals and corrosives . . . pressures to 150 psi . . . temperatures from —120°F. to +500° F. Supplied in metallurgical specification best suited to the service.

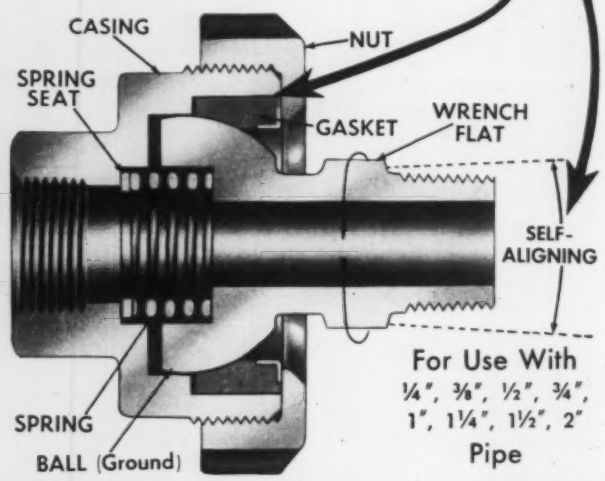
Crane Packing Co., 6425 Oakton St., Morton Grove, Ill. (Chicago Suburb)
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

JOHN CRANE CRANE PACKING COMPANY

Circle 525 on Page 19

TWO BIG ADVANTAGES!

1. Self-Aligning Ball
2. Self-Adjusting Seal



BARCO SWIVEL JOINTS

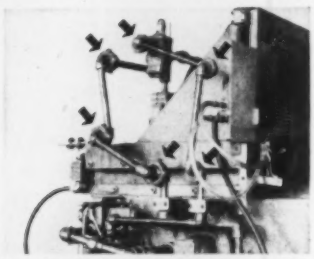
—Make Piping Flexible!

Two important features give Barco Swivel Joints capabilities not found in ordinary swivel joints:

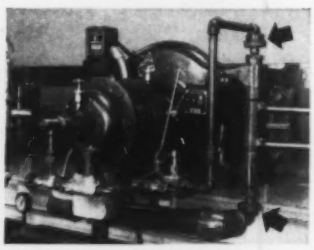
SELF-ALIGNING—Provides a wide tolerance for pipe fitting and machine alignment. Saves endless hours installation time and permanently protects against binding and wear.

SELF-ADJUSTING SEAL—Pressure sealing and automatically self-adjusting for wear. Ideal for hydraulic service. Uniform performance over wide temperature range. Long life. No lubrication needed.

Send for Catalog 265B, "Barco Self-Aligning Swivel Joints." Ratings as high as 750 psi steam or 3000 psi hydraulic. Sizes ¼" to 2"; angle or straight. *Ask for recommendations—Barco is at your service.*



15,870 HOLES PER MINUTE—Six Barco Swivel Joints (see arrows) in "dog leg" piping provide flexible connections to moving hydraulic cylinder on acoustic tile hole drilling machine. 800 psi operating pressure; ⅜" to 1" stroke, 30 per minute.



OIL BURNER—Two Barco Swivel Joints (see arrows) mounted as pivot points on hinge provide swivel connections for fuel oil and steam atomizing lines to door mounted oil burner.

FOUNDED 1908 BARCO PRODUCTS BACKED BY EXPERIENCE

BARCO MANUFACTURING CO.
506G Hough Street • Barrington, Illinois

The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Revolving Joints
In Canada: The Holden Co., Ltd., Montreal

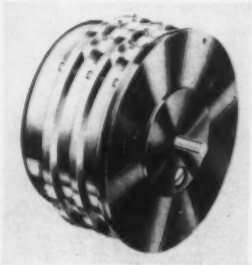
age between contact carrier and magnet is floating so that no vibration or shock is transmitted. Relays are available in NEMA 1 general-purpose enclosures. **Clark Controller Co.**, 1146 E. 152nd St., Cleveland, Ohio. F

Circle 706 on Page 19

Potentiometer

has all moving parts sealed in oil

New oil-filled potentiometer provides longer life, reduced noise, increased dielectric strength, greater heat dissipation, and more positive watertightness than standard potentiometers. Three multiturn versions



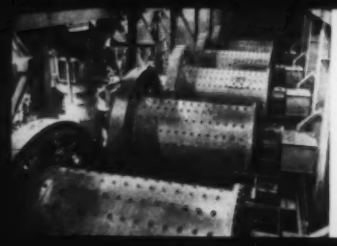
are available as standard models for servo mounting: a ten-turn, 1 1/16-in. diam unit; a three-turn, 2-in. model; and a ten-turn, 2-in. model. Two and 3-in. diam single-turn units will also be available, as well as units made to specifications. **Helipot Corp., Div., Beckman Instruments Inc.**, Newport Beach, Calif. L

Circle 707 on Page 19

DC Power Supply

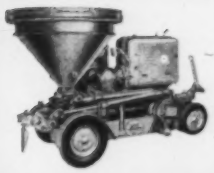
for low-voltage applications

Model 721A transistorized dc power supply, designed for use in transistor circuit development and other low-voltage applications, has an output of 0 to 30 v, continuously variable. Regulation, no load to full load, is 0.3 per cent or 30 mv, whichever is greater, insuring stable fixed parameters during tests regardless of line or load variations. Front panel switch sets maximum current that can be drawn, even with output short-circuited, preventing damage to transistors in case of accidental overloads. Three-terminal output makes it possible to connect ground to either positive or negative



ALLIS-CHALMERS

TSP spur gears, spur pinions on Vibrating Screens and Ball Mills



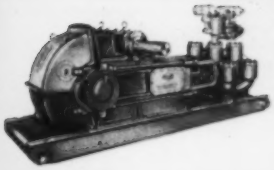
CHAIN BELT

TSP hardened products on Pumpcrete Cylinders

GENERAL AMERICAN

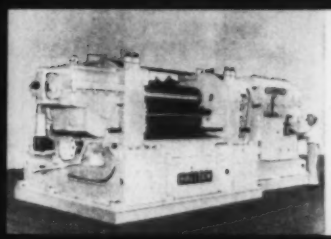
TSP trunnion rollers on Dryers

Why do these equipment builders use TSP hardened products?



WHELAND

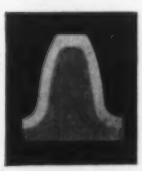
TSP gears and pinions on Slush Pumps



HALLDEN

TSP gears, pinions, racks on Flying Shears

"Tool Steel Process" hardened products when used as components, virtually eliminate replacement problems. Fewer replacement expenses, maintenance savings, reductions in costly "downtime" mean greater customer satisfaction. That's why Allis-Chalmers Manufacturing Company, Chain Belt Company, General American Transportation Corporation, The Wheland Company and The Hallden Machine Company and many more use TSP hardened products to increase the over-all quality and life of their equipment. Here are a few reasons why TSP hardened products are so desirable. They are phenomenally long wearing, a result of our special hardening process. The file hard surface to the full depth of permissible wear gives maximum life. The core, refined for toughness and ductility, gives maximum strength. Note even depth of hardness of gear tooth cross section.



TSP hardened products are made to order from your blue prints or to fit existing equipment. They include gears, pinions, track wheels, sheave wheels, axles, rolls, bushings, liners, sprockets, screw down screws and nuts, shafts, drive clutches, trunnions, hoist drums and many others. Gears are made in sizes to 90" diameter. Other products up to 22,500 lbs. They are guaranteed in writing to outlast, out-perform any competitive part in the same service.

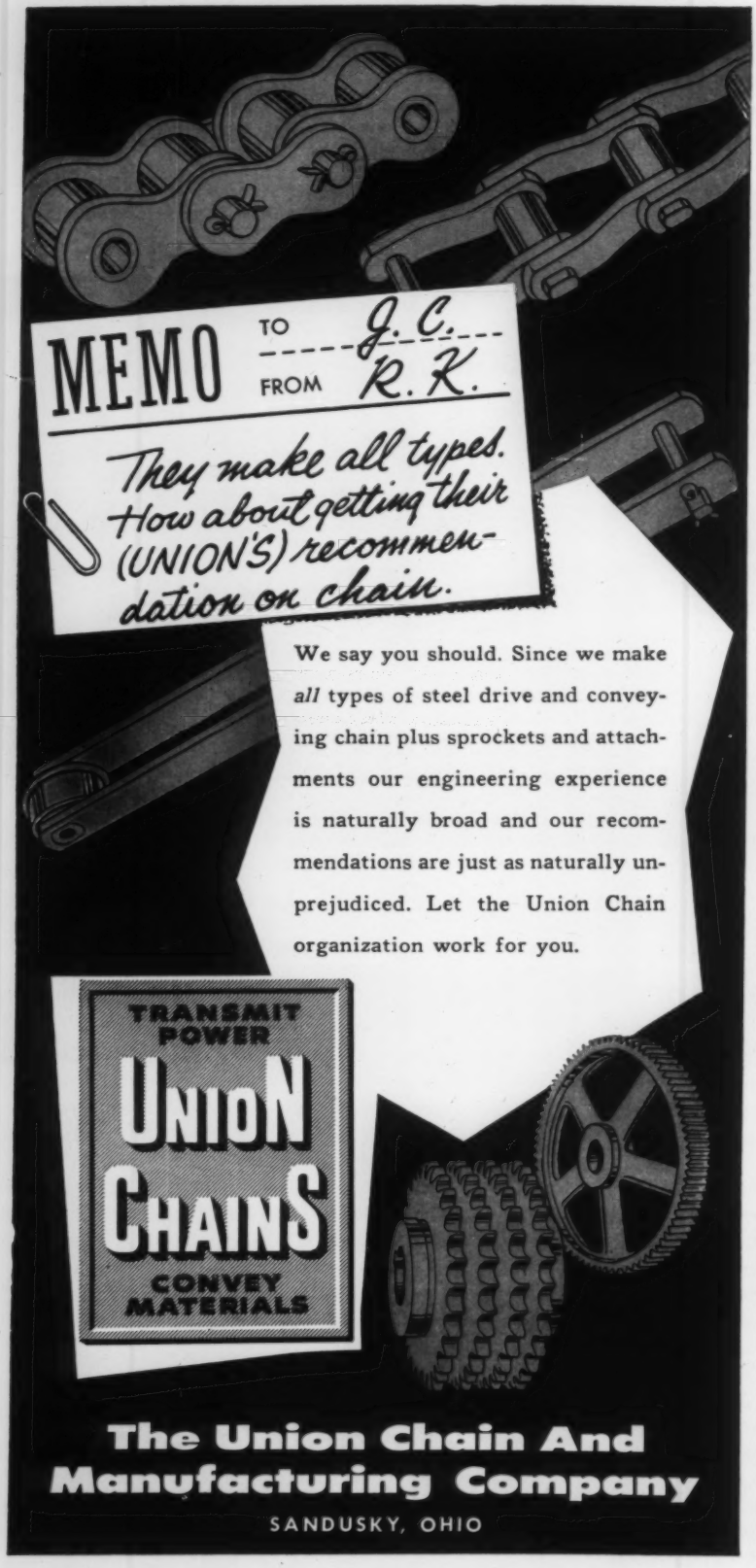
Write for free Bulletin 352, "Why Are They Called TSP Products"

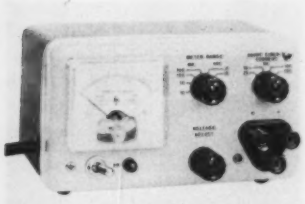
THE TOOL STEEL GEAR AND PINION CO.
CINCINNATI 16, OHIO, U.S.A.

AD 1032

The Standard of Quality Since 1909 for Gears • Pinions • Rolls • Wheels and Other Hardened Products

Circle 527 on Page 19


MEMO
TO J. C.
FROM R. K.
They make all types. How about getting their (UNION'S) recommendation on chain.
We say you should. Since we make all types of steel drive and conveying chain plus sprockets and attachments our engineering experience is naturally broad and our recommendations are just as naturally unprejudiced. Let the Union Chain organization work for you.
TRANSMIT POWER
UNION CHAINS
CONVEY MATERIALS
The Union Chain And Manufacturing Company
SANDUSKY, OHIO



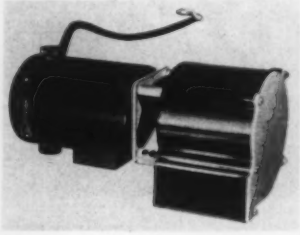
terminal, or to float the unit on top of another voltage. Supply, equipped with floating chassis, weighs 4 lb. **Hewlett-Packard Co.**, 275 Page Mill Rd., Palo Alto, Calif. M

Circle 708 on Page 19

Centrifugal Blowers

for cooling of electronic equipment

New, compact centrifugal air-moving units for military and commercial electronic equipment cooling are available in a variety of sizes and arrangements. They are furnished with single or double inlets, single or double wheels, direct or V-belt drive, and offset or direct discharge. Broad selection of materials is also provided. Unit shown measures 4 in. in diam by 8 in. long. It delivers 80 cfm at 1.5 in. water gage



static pressure. Totally enclosed, 1/10-hp electric-drive motor operates at 8000 rpm. Blower operates satisfactorily at static pressures to 4 in. water gage. **American Blower Div., American-Standard,** Detroit 32, Mich. H

Circle 709 on Page 19

Tilting Motor Base

for 1 to 3-hp motors

New tilting motor base, which provides correct belt tensioning at all times, is designed fo use with variable-pitch pulleys. Available for 1 to 3-hp motors, it also permits convenient, easy belt changing on cone-step pulleys. Exact speed control

Circle 528 on Page 19

Frank W. Springsteen, left, senior planning delineator, points out to Joseph F. Reilly, director of the bureau of office services in N. Y. State's department of public works, the high quality and contrast of an 11" x 17" reduction run off on an offset duplicator from a paper master prepared xerographically from an original 22" x 34" highway drawing.

New York State is saving $120,000 yearly on

- HIGHWAY CONSTRUCTION PLANS
- SPECIFICATION BOOKS
- PREPRINTED FORMS OF ALL KINDS

Xerography and offset duplicating are saving the New York State department of public works $120,000 yearly. This is an amount expected to grow, since the state is finding more and more uses for the versatility of xerography, a clean, fast, dry, electrostatic process copying —in enlarged, reduced, or the same size—anything written, printed, typed, or drawn.

The New York State department of public works uses XeroX® Model 1218 copying equipment in the quantity reproduction of highway construction plans for bidders and contractors, specification books, and preprinted forms of all kinds.

This equipment reduces, with fine legibility, drawings as large as 24" x 36" onto the 12" x 18" confines of an offset paper master, from which multiple copies are run off on an offset duplicator.

The handier print size achieves economies in space, time, materials, handling, and postage. Hand shearing and hand collating are eliminated as well as a great deal of proofreading. Portability and lower cost of the new prints have increased demand by 25%.

Write us for proof-of-performance folder showing how New York State is speeding paperwork and is saving $120,000 yearly by xerography. Haloid XeroX Inc., 58-187X Haloid Street, Rochester 3, N. Y. Branch offices in principal U. S. and Canadian cities.

HALOID XEROX®

Circle 529 on Page 19

ORDINARY CHAIN BREAKS when the side plate tires from repetitive loading and unloading during the cycle around the sprockets. But Morse H-E Roller Chain has a 95% higher endurance limit and outlasts ordinary chain by up to 5 to 1.

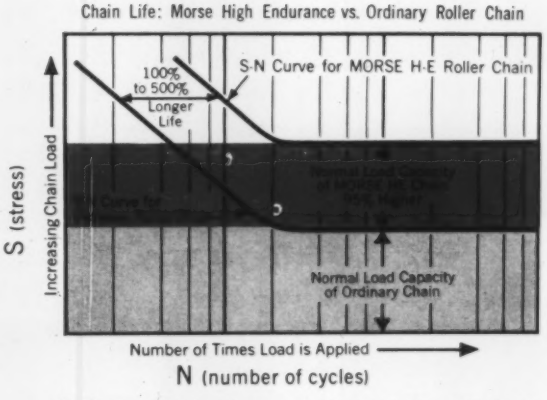
"Tired Metal"... the bane of chain now licked by MORSE H-E

Morse H-E Roller Chain has up to 500% longer service life . . . cuts replacement and labor costs

The unretouched photograph shows what happens to chain when the metal fatigues. But now a special Morse process has licked the "tired metal" problem. It gives Morse H-E Roller Chain 95% higher endurance limit . . . and up to 500% longer service life.

The special process means Morse H-E Chain costs about 10% more. But that's a small price to pay for a heavy-duty chain that can save you thousands of dollars annually in replacement costs, downtime, and wasted man-hours.

For more information on the chain that licked the "tired metal" problem once and for all, see your local Morse Distributor. Or write: MORSE CHAIN COMPANY, Dept. 6-68, Ithaca, New York. Export Sales: Borg-Warner International, Chicago 3, Illinois.


Chain Life: Morse High Endurance vs. Ordinary Roller Chain
100% to 500% Longer Life
S-N Curve for MORSE H-E Roller Chain
Increasing Chain Load
S (stress)
Normal Load Capacity of Ordinary Chain
Number of Times Load is Applied
N (number of cycles)

Red area: Under these chain loads, fatigue will break ordinary chain . . . but *not* Morse H-E.

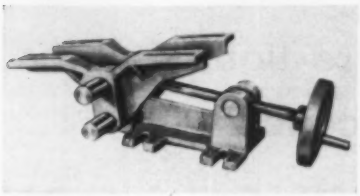
White area: Under these loads, fatigue will break ordinary chain and Morse H-E . . . but Morse H-E will have operated 100% to 500% longer.

IN POWER TRANSMISSION
THE TOUGH JOBS COME TO

MORSE BW

*Trademark

REMEMBER: Only Morse offers you all four of these basic drives: Roller Chain, Silent Chain, Hy-Vo®, and "Timing"® Belts.



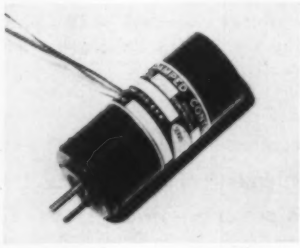
is maintained by hand-screw adjustment. Base, which fits both new and old NEMA frame sizes, can be mounted in any position. Size is 9⅝ x 20¼ in. **Lovejoy Flexible Coupling Co.**, 4882 W. Lake St., Chicago 44, Ill. J

Circle 710 on Page 19

Servo Motors

Size 11 units have inertial damper

New 400-cycle servo motors in BuORD size 11 have an inertial damper which gives no reduction in speed or output power at constant velocity. Standard unit, designated 11P1-3, operates directly from a 115-v line, and has 40-v center-tapped control-phase winding. Minimum no-load speed is 6200 rpm and minimum stall torque is 0.60 oz-in. Units can be furnished with an integral precision gearhead with ratios up to 16,000:1. One-piece



housing for motor damper and gearhead minimizes alignment and assembly problems. **Mechatrol Div., Servomechanisms Inc.**, 1200 Prospect Ave., Westbury, L. I., N. Y. D

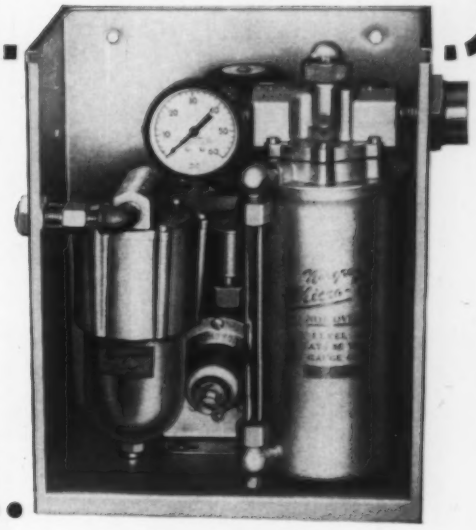
Circle 711 on Page 19

Switches

for liquid, gas, or water systems

New stripped pressure and vacuum switches are for OEM and industrial installations where controls are enclosed in a common cabinet. Insensitive to vibration, units operate in any position and can be mounted

Norgren MICRO-FOG LUBRICATION

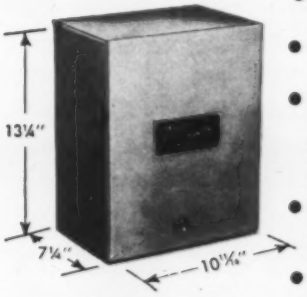


NEW...

Compact, Tamper-Proof Cabinet Units

lubricate all bearings, gears, chains and cams on a machine

These new Norgren units provide ideal lubrication by applying just the right amount of air-borne oil fog to all bearing surfaces. The standard unit includes an automatic-drain air line filter, a solenoid valve, a pressure regulator, a pressure switch and a MICRO-FOG Lubricator... *and provides the following important advantages:*



1 QT. OR 2 QT. OIL CAPACITY
200 OR 300 BEARING INCH RATING

- **TAMPER-PROOF**—Totally enclosed key-locked cabinet prevents tampering.
- **SPLASH-PROOF**—Coolant and corrosive liquids cannot reach interior of enclosure.
- **CONVENIENT TO SERVICE**—Removable one-piece top and side panel—secured by key lock—provides easy access for authorized personnel. Visual oil feed is proof of lubrication. Oil level gauge glass provided on lubricator.
- **SAFEGUARDS MACHINE COMPONENTS**—Pressure switch actuates alarm or shuts down machine if air pressure fails.
- **HEATER AND OIL LEVEL CONTROL OPTIONAL**—Thermostatically-controlled Heater, for 1 Qt. units, maintains lubricant temperature and viscosity. Oil level control actuates alarm or stops machine when oil needs replenishing.

For complete information, call your nearby Norgren Representative listed in your telephone directory—or WRITE FACTORY FOR NEW No. 900 CATALOG

C. A. NORGREN CO.

If it's Norgren... It's Dependable.

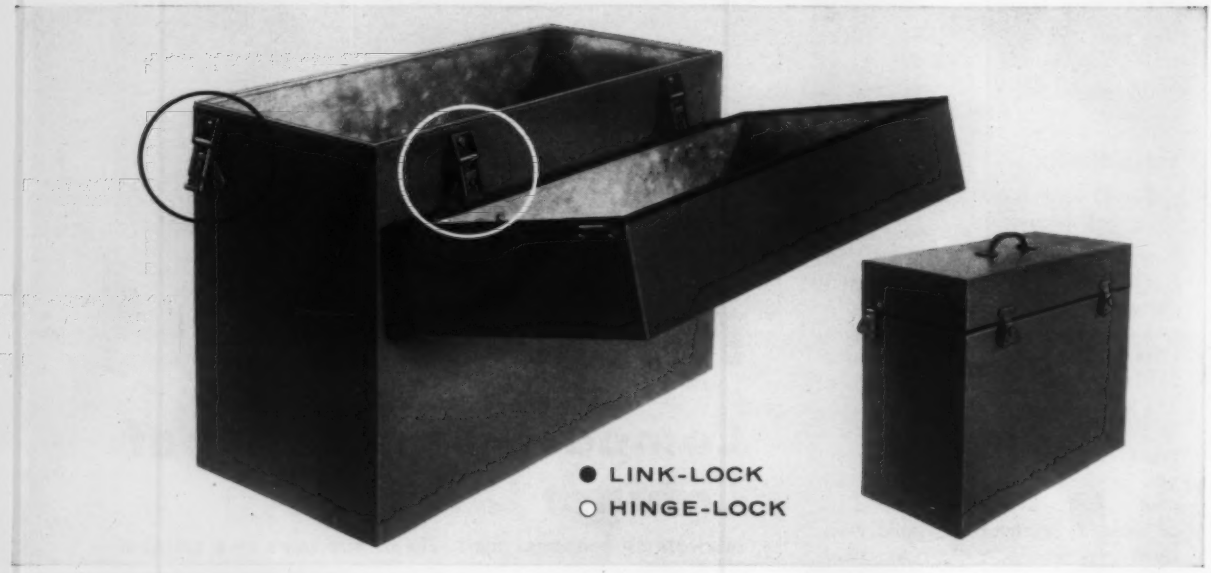
3442 SOUTH ELATI STREET ENGLEWOOD, COLORADO

Circle 531 on Page 19

Now

An all-around pressure-tight seal for hinged-cover transit cases with

LINK-LOCK and HINGE-LOCK



No. 3 LINK-LOCK

No. 3 HINGE-LOCK

Two HINGE-LOCK and two LINK-LOCK Fasteners provide all-around sealing pressure on this container manufactured for the U.S. Navy by the Bonded Structures Division, Swedlow Plastics Company.

The new Simmons HINGE-LOCK, used in combination with LINK-LOCK, provides an even, pressure-tight seal on equipment containers and transit cases with hinged covers. A half-turn applies pressure to both types of fasteners. When pressure is released HINGE-LOCK becomes a free-operating hinge, and LINK-LOCK disengages to permit opening.

Originally developed by Simmons Fastener Corp. for the Engineering Department of Swedlow Plastics Company, Bonded Structures Division, HINGE-LOCK is similar in principle and appearance to LINK-LOCK. Both are available in light and medium duty sizes as matched hardware. LINK-LOCK is also available in a higher-capacity, heavy-duty size.

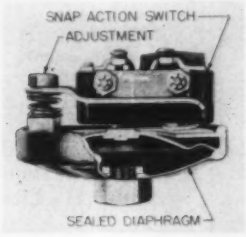
SEND TODAY for complete data, including dimensions, capacities. Engineering service is available... Outline your requirements. Samples on request.

See our 8 page catalog in Sweet's 1958 Product Design File

SIMMONS FASTENER CORPORATION 1756 North Broadway, Albany 1, New York

QUICK-LOCK • SPRING-LOCK • LINK-LOCK • HINGE-LOCK • ROTO-LOCK • DUAL-LOCK

directly on moving or vibrating equipment. Recommended for liquid, gas, or water systems, units sense any system pressure over an adjustable range of 30 in. Hg vacu-



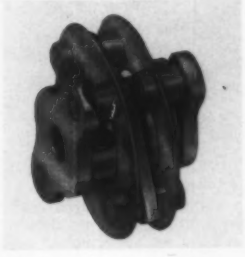
um to 100 psi pressure, and actuate an electric circuit at predetermined pressure, on both increasing and decreasing pressures. **Pressure Switch Div., Barksdale Valves,** 5125 Alcoa Ave., Los Angeles, Calif. L

Circle 712 on Page 19

Flexible Servo-Coupling

is 7/16 in. long and ¾ in. in diameter

New servo-coupling has zero backlash, low inertia, and high flexibility. It is 7/16 in. long by ¾ in. in diameter, with bores available in any diameter from 1/16 through 3/16 in. and in any combination. Misalignments permissible are ±5 deg angular and ±0.015 deg linear.



Torque capacity is 30 oz-in., and weight is as low as 0.19 oz. **Renbrandt Inc.,** 6 Parmelee St., Boston 18, Mass. B

Circle 713 on Page 19

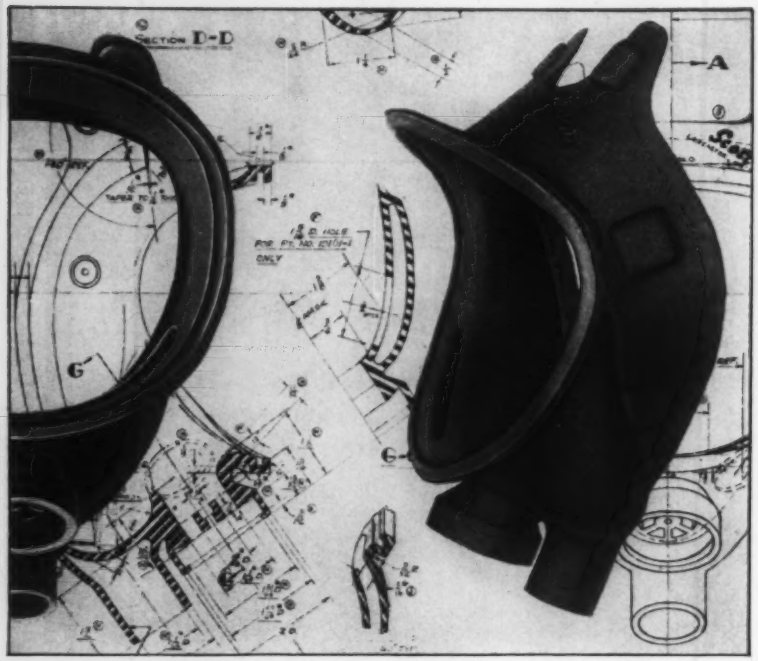
Wire Joint

has flared entrance opening

Sta-Kon wire joint is of one-piece, high-strength bronze. It features a flared entrance opening to protect wires from nicking and breaking, and an open end to allow quick inspection. Two sizes take a maxi-

serving the new "Air Ride"
Chemiseal® Nylon Pressure Tubing outperforms metal at a fraction of the cost.
This light, strong, flexible tubing connects the various components of the pneumatic system which provides the new "Air Ride" offered by 1958 motorcars. In this job, it meets stringent performance requirements at a fraction of the cost of metal tubing with required flexible couplings and intermediate fittings. It saves assembly time and costs, too, because it's easier to install.
Chemiseal Nylon Pressure Tubing is available in 1000 psi and 2500 psi grades, which conform to J.I.C. specifications for low and medium pressures. Advantages include: high pressure rating at low cost; long flex and vibrational life; resistant to oils, greases, solvents, chemicals; wide service temperature range; crush and abrasion resistant; adaptability to standard metallic fittings. Use Chemiseal Nylon Pressure Tubing at a profit on pressure lubrication lines, hydraulic and pneumatic systems, oil and fuel lines, chemical and food processing lines, vacuum system connections, etc.
For prompt service, contact one of The Garlock Packing Company's 30 sales offices and warehouses in the U. S. and Canada, or write
United States Gasket Company
Camden 1, New Jersey
United States Gasket
Plastics Division of
GARLOCK

Circle 533 on Page 19



Courtesy Scott Aviation Corp.

New Molded Profile Reveals Techniques for Better Rubber Specs

In the early stage of planning and design, it was questionable whether this face mask could be molded in rubber—in one piece—practically, yet economically . . . and here's why.

It calls for an ingeniously designed and machined mold to provide for facial contours, air inlets and outlets, undercuts, feathered edges, valve mounts, fastenings, etc.—one of the hardest-to-fill cavities ever encountered. Also, the rubber must be compounded to flow freely inside this complicated form and still maintain its knitting qualities. How was this accomplished?

While the mask was still in the design stage the customer realized the importance of consulting a rubber specialist. From this conference came an exchange of suggestions which led to a practical and functional design that permits molding these masks with unusual speed and economy. Here's the idea.

While a job is still on the drawing board consult with rubber specialists. Suggestions can often be made to eliminate high tooling costs or high priced compounds. End results give you better rubber parts, better performance and lowest cost. Regardless of how simple or complex your rubber needs may be call Continental—specialists since 1903.

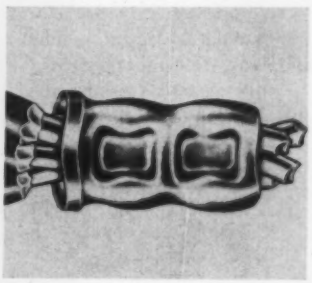
Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**

engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1984 LIBERTY ST. • ERIE 6 • PENNSYLVANIA



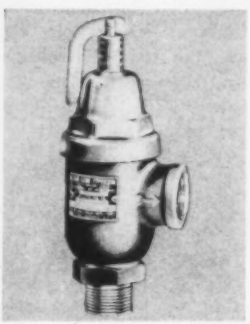
mum of four No. 10 and four No. 12 wires, respectively. **Thomas & Betts Co.**, 36 Butler St., Elizabeth, N. J. D

Circle 714 on Page 19

Automatic Valves

combine temperature and pressure relief

Type FV automatic valves, for automatic storage-type water heaters, storage tanks, and booster heaters, are self-closing combination temperature and pressure-relief units. Eleven different models provide a selection of pipe sizes, male or female inlet connections, with or without fixture connections. Valves are bronze and incorporate a ther-



mostatic element which actuates unit when temperatures become too high. They meet MIL-V-13612 as amended. **A. W. Cash Valve Mfg. Corp.**, P.O. Box 191, Decatur, Ill. I

Circle 715 on Page 19

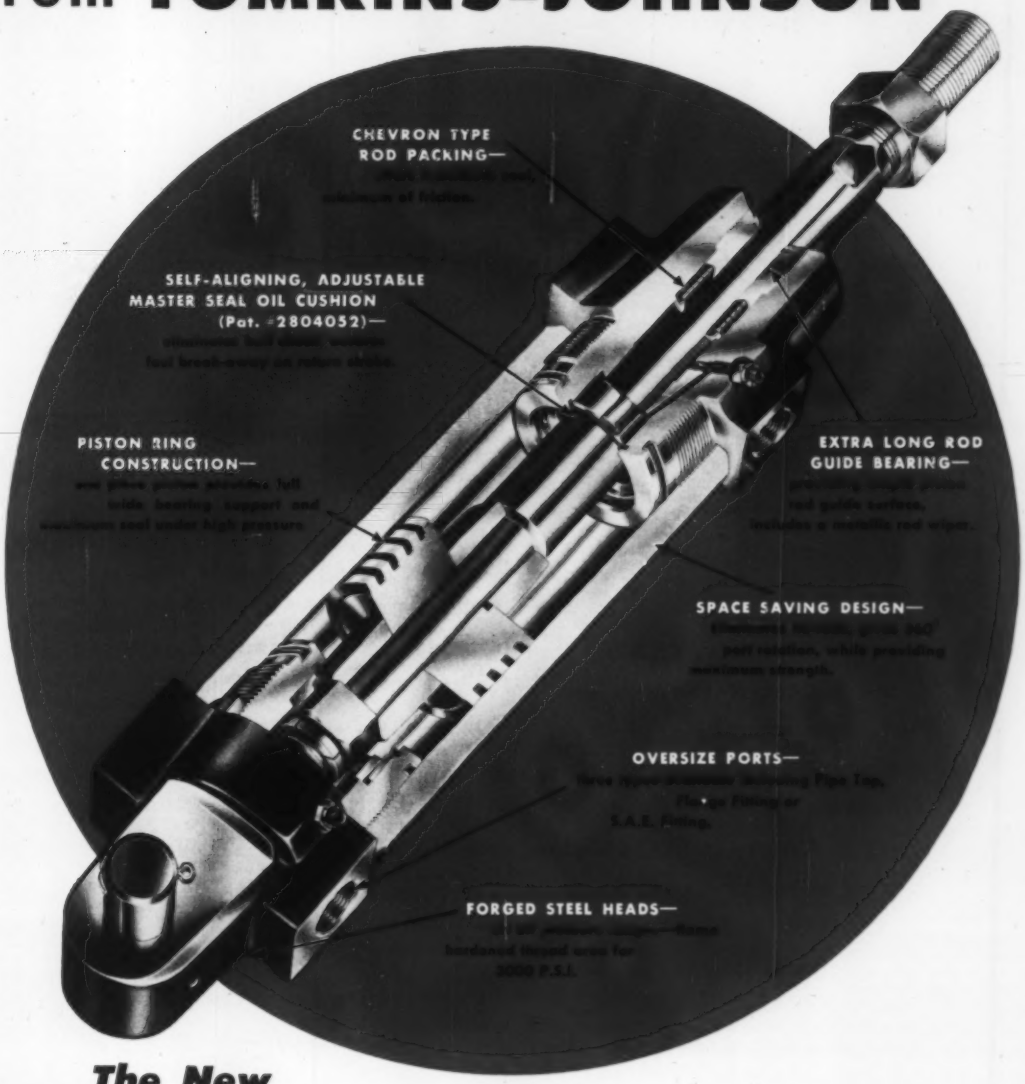
Clutches and Brakes

magnetic units are multiturn, moving-coil types

Redesigned magnetic clutches and brakes are compact, lightweight units which are readily fitted to standard shafts, and can be used on standard breadboard setups. The multiturn, moving-coil units are supplied in two variations: Type 531, a bevel-gear drive with rotat-

Another Engineering First

from TOMKINS-JOHNSON



The New

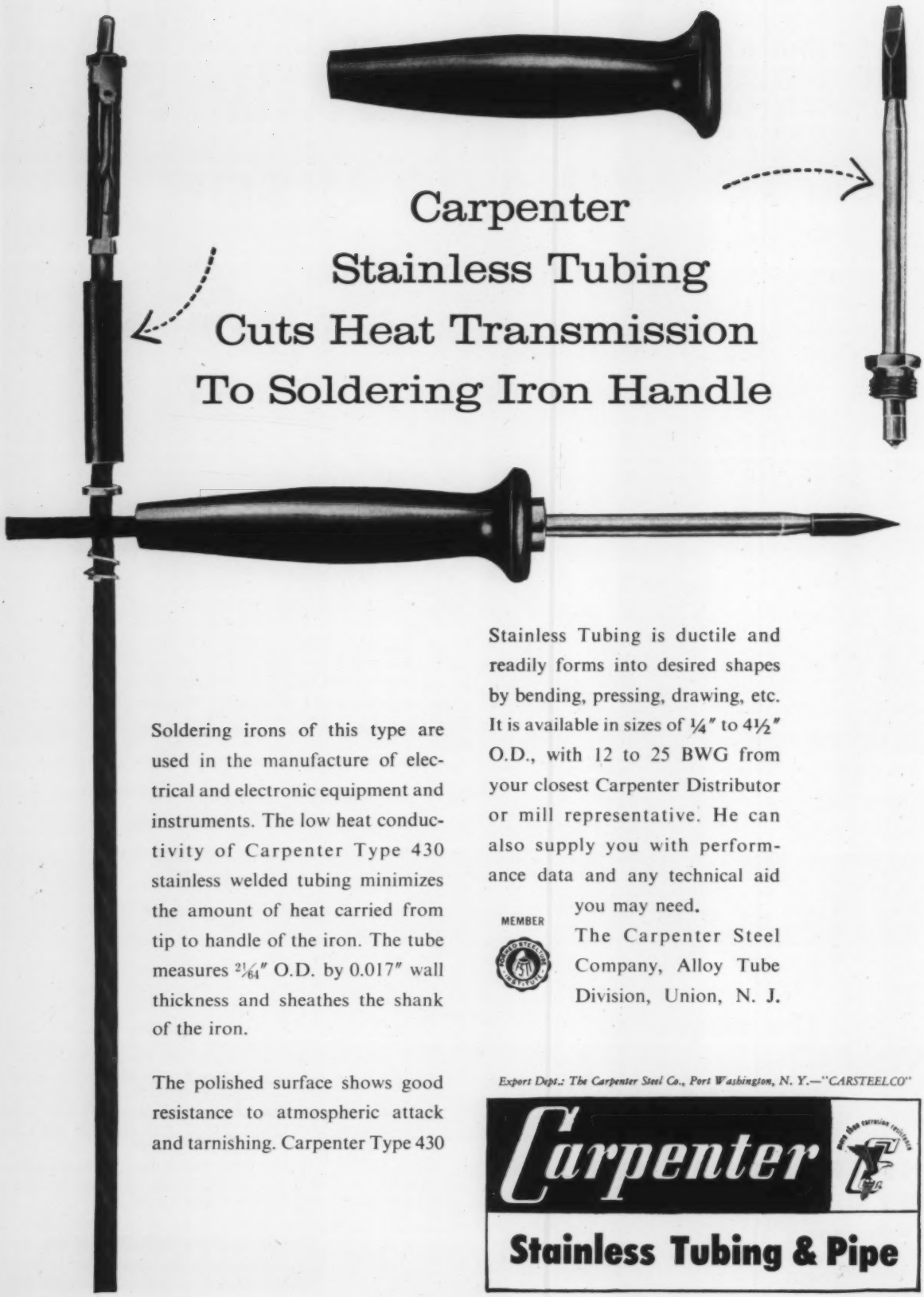
T-J Spacemaker

HIGH PRESSURE HYDRAULIC CYLINDER

1000
● 2000 P.S.I. Operating Pressure
3000

Truly another engineering first from Tomkins-Johnson, the new T-J Spacemaker High Pressure Hydraulic Cylinder will provide quality power performance at high operating pressures. ONLY T-J OFFERS YOU A HYDRAULIC CYLINDER WITH ALL THESE EXTRAS—*STANDARD,* AT NO EXTRA COST. Write to The Tomkins-Johnson Company, 617 N. Mechanic Street, Jackson, Michigan, for further details and Bulletin No. HSM-5-58.

T-J TOMKINS-JOHNSON
DIVERTORS · AIR AND HYDRAULIC CYLINDERS · CUTTERS · CLINCHERS



Carpenter Stainless Tubing Cuts Heat Transmission To Soldering Iron Handle

Soldering irons of this type are used in the manufacture of electrical and electronic equipment and instruments. The low heat conductivity of Carpenter Type 430 stainless welded tubing minimizes the amount of heat carried from tip to handle of the iron. The tube measures $2\frac{1}{64}$" O.D. by 0.017" wall thickness and sheathes the shank of the iron.

The polished surface shows good resistance to atmospheric attack and tarnishing. Carpenter Type 430 Stainless Tubing is ductile and readily forms into desired shapes by bending, pressing, drawing, etc. It is available in sizes of ¼" to 4½" O.D., with 12 to 25 BWG from your closest Carpenter Distributor or mill representative. He can also supply you with performance data and any technical aid you may need.

MEMBER

The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

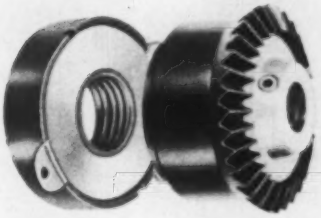
Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Carpenter

Stainless Tubing & Pipe

Circle 536 on Page 19

ing contact fingers and fixed slip ring which is part of a No. 3/8-32 nut for fastening bushing-mount potentiometers to a panel; and Type 521, a bevel-gear drive with rotating slip ring and fixed contact fingers. Minimum drive torque for



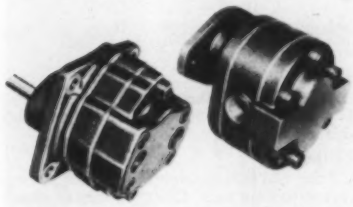
both types is 10 oz-in. and minimum drag torque is 0.5 oz-in. **Hycor Div., International Resistance Co.,** 12970 Bradley Ave., Sylmar, Calif. L

Circle 716 on Page 19

Pumps and Motors

for continuous pressures to 1500 psi

Powermax hydraulic pumps and fluid motors are available in seven different models with pump capacities from 1.2 to 14.2 gpm. Pumps and motors are provided for speeds to 3600 rpm, and are designed for continuous pressures to 1500 psi. Units are of the gear type, have heavy-duty antifriction bearings, double-lip shaft seals, and heavy-



duty outboard ball bearings for overhung shaft loads. **Tuthill Pump Co.,** Dept. RP, 953 E. 95th St., Chicago, Ill. J

Circle 717 on Page 19

Latching Relay

is of one-coil design

Type W impluse latching relay features an insulated rocker arm activated by a single coil. Contacts are set up in one position when coil is energized or pulsed

Specify
BIJUR
AUTOMATIC LUBRICATORS

For DESIGN, SERVICE AND RESEARCH are part of every Bijur System

Consider Design — All Bijur pumps are designed to be an integral part of your equipment not a cumbersome attachment. Compact modern designs permit easy adaptation, enabling operation of the pump by means of gear, belt or chain drive or independently operated by electrical or hydraulic set-ups.

How you benefit — Custom-engineered Bijur automatic lubricating systems save production time and repair bills. Down-time and fire risks are sharply reduced. Costly hand oiling is eliminated and every bearing gets the right amount of oil when needed — there's no chance of under oiling or over oiling.

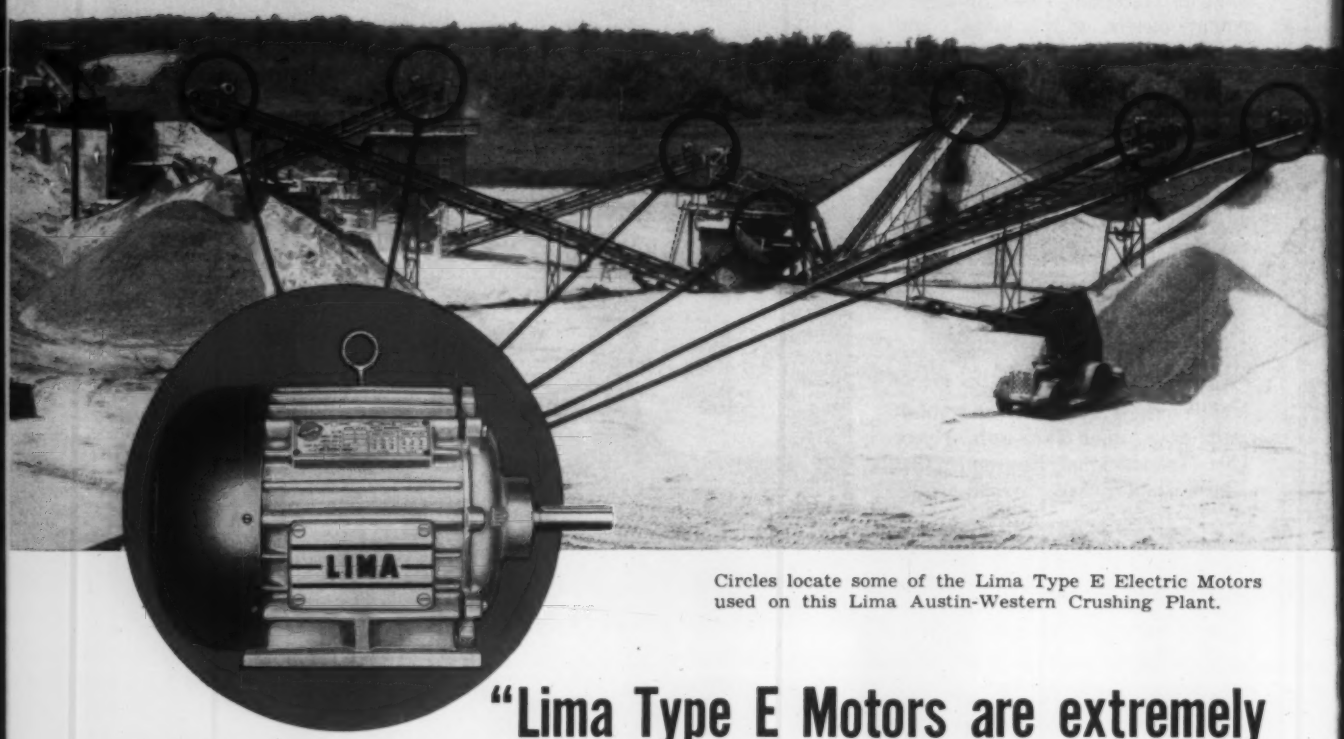
Day-in, day-out Bijur Systems are proving their value to designers, plant engineers and production men on the equipment they design, use, or manufacture. Write today for all the facts about Bijur automatic lubricating systems!

BIJUR AUTOMATIC LUBRICATORS—STANDARD EQUIPMENT IN MANY INDUSTRIES
Machine Tools • Business Machines • Printing Machinery • Textile Machinery • Food Product Machines • Bottling Machines • Packaging Machines • Sheet Metal Machines • Plastic Fabricating Machinery • Glass Products Machinery • Wood-Working Machinery • Industrial Sewing Machines • Special Process Equipment

BIJUR
LUBRICATING CORPORATION
Rochelle Park, New Jersey
Pioneers in Automatic Lubrication

Circle 537 on Page 19

WHY DOES LIMA AUSTIN-WESTERN SELECT LIMA TYPE E MOTORS FOR ROCK CRUSHING SERVICE?



Circles locate some of the Lima Type E Electric Motors used on this Lima Austin-Western Crushing Plant.

"Lima Type E Motors are extremely rugged with plenty of power and an excellent performance record in heavy-duty rock crushing service..."

says Al Bellows
Construction Equipment Division
Baldwin-Lima-Hamilton Corporation

Lima Type E (TEFC) Motors are the original equipment choice for Lima Austin-Western Electrically Driven Crushing, Screening and Washing Plants.

Al Bellows, Sales Manager for Baldwin-Lima-Hamilton Corporation Crushing Equipment, summarizes at right the reasons for their selection. These features of Lima Type E (TEFC) Motors help make Lima Austin-Western Plants (stationary or portable) more efficient in producing high tonnages of aggregate in accurately controlled sizes.

- **MAINTENANCE-FREE**
  Lima Type E (TEFC) Motors are lubricated for life—they require absolutely no maintenance.
- **HIGH CAPACITY BEARINGS**
  Heavy duty DOUBLE-WIDTH ball bearings (prelubricated, protected and sealed) withstand the heavy loads and shocks present in rock crushing service.
- **TROUBLE-FREE OPERATION**
  Lima's specially designed shroud protects the motor from the hazards of rock-crushing service. Rock particles cannot cause motor damage—plants stay in operation.
- **AMPLE SAFETY FACTORS**
  Lima Type E (TEFC) Motors have plenty of reserve power to maintain top operating efficiency under peak loads—and in continuous service.
- **SPACE SAVING FRAMES**
  Furnished in new NEMA frames, Lima Type E (TEFC) Motors are easily installed—they help solve design, weight and space problems by providing maximum power in minimum motor area.

FOR FULL DETAILS OF THE COMPLETE LIMA ELECTRIC MOTOR LINE, CONTACT YOUR NEAREST LIMA ELECTRIC MOTOR DISTRIBUTOR, OR WRITE TO THE LIMA ELECTRIC MOTOR CO., INC., LIMA, OHIO

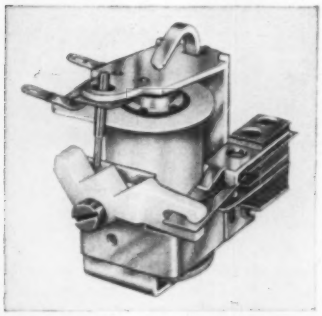
THE LIMA ELECTRIC MOTOR CO., INC., 4894 Findlay Road Lima, Ohio

Representation throughout the U. S., Canada and abroad

LIMA ELECTRIC MOTORS

FIRST...FOR MOTORS...DRIVES...SPEED REDUCERS

Circle 538 on Page 19



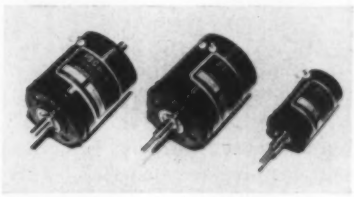
and return to first position on next pulse. Switch changes to opposite position each time coil is energized. Applications include use in machine controls, appliances, positioning devices, television remote controls, and other applications where opposite switching is desired each time circuit is pulsed. Relay is available for either ac or dc operation, with rating of 7½ amp, 115 v ac, resistive, and ⅓ hp, 115/220 v ac. **Comar Electric Co.**, 3349 W. Addison St., Chicago 18, Ill. J

Circle 718 on Page 19

Clutches and Brakes

for speeds to 5000 rpm

Type DX magnetic clutches and brakes are available in 1 1/16 in. diam, size 11 frame, and 1¾ in. diam, size 18 frame. Torque range is from 8 to 40 oz-in. Units are



for speeds up to 5000 rpm. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, L. I., N. Y. D

Circle 719 on Page 19

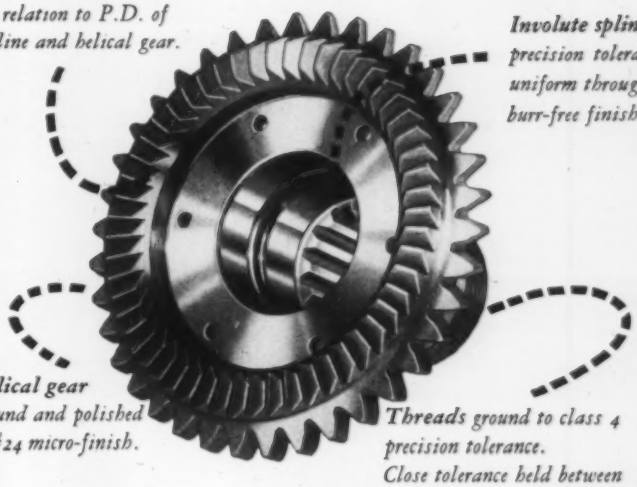
Relay

is enclosed in plastic case that withstands heavy impact

Series 1210 relay is encased in a dust-tight, transparent plastic enclosure that withstands heavy impact. Unit is unaffected by weather and resists temperatures to 200 F. Contact rating is 8 amp, 115 v, 60 cycle, noninductive. Relay is available in any ac voltage rating from

Generated clutch held at close tolerance in relation to P.D. of spline and helical gear.

Involute spline, precision tolerance, uniform throughout, burr-free finish.



Helical gear ground and polished to #24 micro-finish.

Threads ground to class 4 precision tolerance. Close tolerance held between thread and P.D. of helical gear.

DON'T GAMBLE WITH GEAR PERFORMANCE

YOU know that gambling with gears can cost you money — production delays, costly rejects, failures in use. You don't want to take chances with your customers . . . they expect day-in, day-out performance from your machines. Your performance guarantee can be Perkins custom-cut gears . . . precision gears made to your exact specifications. Perkins' 52 years of gear-making know-how, extensive facilities and equipment, and rigid production controls assure uniform tolerances throughout . . *.plus* a consistent micro finish. You get perfect meshing and full capacity from every gear. Many leading manufacturers — Sikorsky, Stanley, Universal Winding, for example — rely on Perkins for top-quality gears, gears that cost less in the long run. Ask us to quote on your next gear requirement. Then judge for yourself.

YOURS ON REQUEST Folder illustrating gears Perkins has made — face gears, generated and curvic clutches; bevel, spiral, helical and spur gears; ratchets, sprockets and ground thread worms — from all materials. Includes Perkins facilities for producing various gear types and sizes. *Write today.*

PERKINS
MACHINE AND GEAR CO.

Dept. 23 West Springfield, Mass.
Telephone: REpublic 7-4751

Circle 539 on Page 19

Capture Your Market By Designing With Townsend Blind Rivets*

Design flexibility
full strength value developed every time
wide grip range

Improved appearance for greater salability
can't mar surfaces
create modern contours and shapes

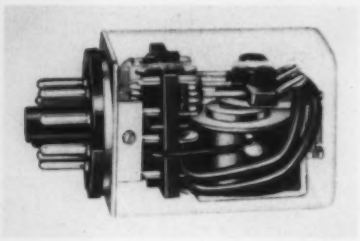
Increased production
rapid one-man installation from one side
no special training required for workers

Reduced customer maintenance
rivets can't vibrate loose, which eliminates the inconvenience and expense of repairs

For full information, write to Townsend Company, P.O. Box 237-E, New Brighton, Pa., asking for Bulletin TL-124.

*Patents issued and pending

Townsend
COMPANY • ESTABLISHED 1816
Sales Offices in Principal Cities
In Canada: Parmeter & Bulloch Manufacturing Company, Limited, Gananoque, Ontario



6 to 230 and any dc voltage from 6 to 110. **Guardian Electric Mfg. Co.**, 1621 W. Walnut St., Chicago 12, Ill. J

Circle 720 on Page 19

Flanges

for polyvinyl-chloride piping system

Flanges with concentric-serrated faces for polyvinyl-chloride piping systems provide better gasket retention, more effective seal, and improved appearance over smooth-face flanges. Fluid is sealed off at the first serration, cannot travel around spiral grooves between serrations until it leaks from flange. Flanges, with approximately 32 serrations per inch, are available in sizes from ½ to 6 in., in both socket

and threaded types, and in normal and high-impact materials. **Tube Turns Plastics Inc.**, 2929 Magazine St., Louisville 11, Ky. G

Circle 721 on Page 19

Bronze Alloy

has high yield and high tensile strength

Silnic Bronze is a corrosion-resistant, nickel-silicon bronze alloy which combines both high yield strength and high ultimate tensile strength, even at elevated temperatures. Metal is age hardenable and is available in soft, cold-forming, and hard tempers. In the hard temper, metal can be machined or given moderate cold working with-

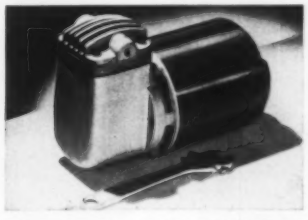
out further treatment. It provides excellent chip breakage and accurate detail when machined. In the cold-forming temper, metal permits easy material flow for fabrication involving severe or complicated cold working. Alloy is free from silicon segregation, has uniform distribution of strength and hardness through entire cross section, is not subject to fire cracking during processing, and has high resistance to general and stress corrosion. It is available in a variety of cross sections and dimensions in straight lengths of rod and bar and coils of round, rectangular, and square rolled and drawn wire. **Chase Brass & Copper Co.**, Waterbury, Conn. B

Circle 722 on Page 19

Diaphragm Pump

for continuous operation delivers oil-free air

Low-volume diaphragm pump which delivers oil-free air is designed for continuous operation. It provides vacuum down to 22 in. Hg, pressure to 40 psi, and maximum displacement of 1 cfm at free flow. Standard electrical requirement is 115 v, 60 cycle. Unit,



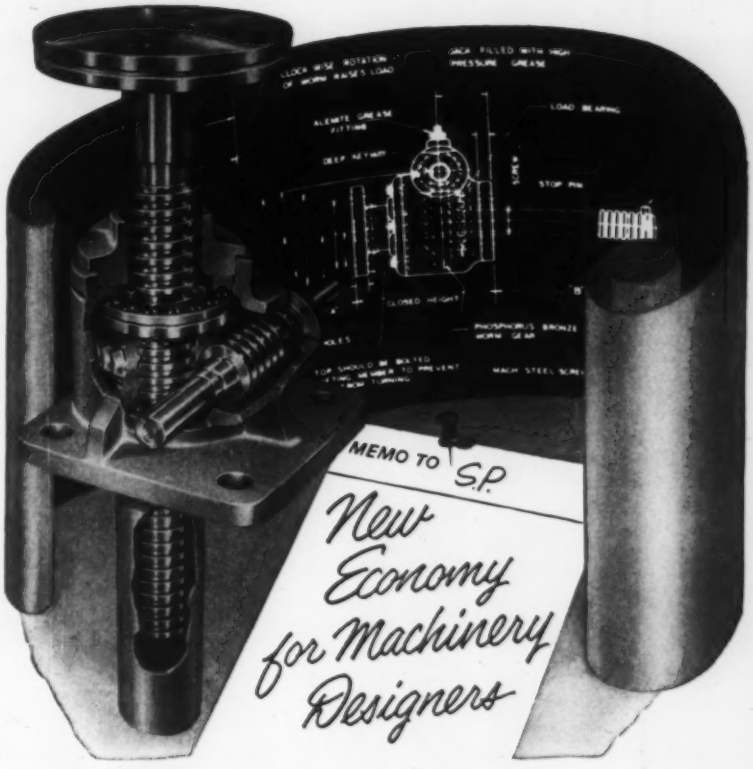
which weighs only 16.7 lb, has neoprene-nylon valve gasket and diaphragm, cannot freeze, rust, or jam. **Air-Shields Inc.**, Hatboro, Pa. E

Circle 723 on Page 19

Binding Posts

five-way units have gold-plated brass parts

New five-way binding posts in six colors have gold-plated, machined brass parts for quicker, easier soldering and maximum electrical contact. Design permits connection by standard ¾-in. banana plug, clip-lead to shaft, wire looped around shaft and clamped, wire permanently clamped through center hole, and



NOW, A STANDARD LINE OF DUFF-NORTON WORM GEAR JACKS

The economies of standardized production now can be realized by machinery designers who use Duff-Norton worm gear jacks for accurate positioning of loads weighing as much as several hundred tons. After 25 years of experience and hundreds of custom designs, Duff-Norton engineers have produced a standard line of eight jacks ranging from 2 to 100 tons in capacity which will meet almost any requirements. When jacks are used in an arrangement, added economy can be realized in raising unevenly distributed loads, since all models now have a uniform raise which permits jacks of varying capacities to operate in unison.

Worm gear jacks are purely mechanical devices, and they can hold heavy loads in position indefinitely without any creep. Functioning as components of machinery or equipment, they can raise or lower loads, apply pressure or resist impact. Worm gear jacks can be furnished with raises up to 24 inches, and they will provide exactly the same raise for years without adjustment.

Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting Bulletin AD-66-V, which includes drawings and full specifications.

DUFF-NORTON COMPANY

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

COFFING HOIST DIVISION • Danville, Illinois

DUFF-NORTON JACKS
Ratchet, Screw,
Hydraulic, Worm Gear

DUFF-NORTON

COFFING HOISTS
Ratchet Lever
Hand Chain, Electric

Circle 541 on Page 19

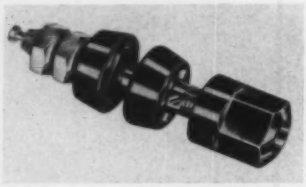
BEAVER
BALL SCREWS

Successor to the Acme screw drive and preferred in many applications to hydraulic and pneumatic systems. Guaranteed 90% efficient in converting rotary twist to linear push (or vice versa). Employs a stream of precision balls and ground lead to eliminate drag and wear in delicate instruments, aircraft, machine tools, massive wind tunnel jacks, etc. For horizontal and vertical actions, indexing, inching and traversing. Consultation and engineering service available. Write for literature.

• EXTREME ACCURATE POSITIONING • NO BACKLASH • RAPID START • ANY DIAMETER OR TRAVEL •

Beaver Precision Products INC.
CLAWSON, MICH.

Circle 542 on Page 19



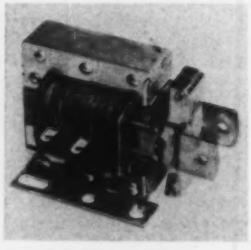
clamped spade-lug connection. Rigid base for permanent solder connection is provided by 1/8-in. flanged tip. Units are hard nylon plastic molded over gold-plated brass core and center shaft. They can be mounted and securely locked in any panel from 1/16 to 1/4 in. thick with complete insulation from panel. Current capacity of 30 amp and 1000-v working voltage permit wide range of applications. **Superior Electric Co., Dept. BP,** 83 Laurel St., Bristol, Conn. B

Circle 724 on Page 19

Solenoids and Transformers

are protected against shock and fire

New solenoids and transformers employ an internal construction which protects the unit against fire and shock. Flash time and arc are reduced to a minimum. Fire-protected design permits the use of cotton



tape in place of glass tape in coil design. Need for thermostats and fuses is eliminated. **Dormeyer Industries,** Dept. MDC, 3418 N. Milwaukee Ave., Chicago, Ill. J

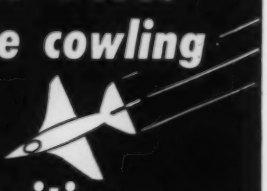
Circle 725 on Page 19

Limit Switch

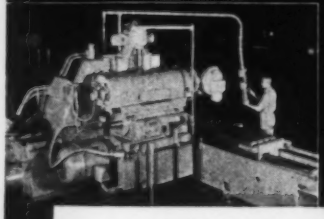
is oiltight, plug-in unit

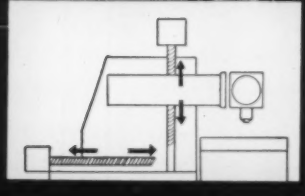
New oiltight, plug-in limit switch provides wide flexibility and is designed for easy installation. Base receptacle can be mounted and wired without disassembly; plug-in switch mechanism is reversible, and can be plugged in with roller arm

The same instrument that opens and closes the cowling



positions heavy cutter heads





Beaver Ball screws provide rapid, positive, horizontal and vertical positioning of the head of this Sundstrand Milling Machine. To demonstrate the advantage of using Beaver Ball Screws this 14,000 pound head is raised at from 1/2 to 50 I.P.M. with zero backlash by a 4 H.P. motor and without bulky, expensive counterbalancing.

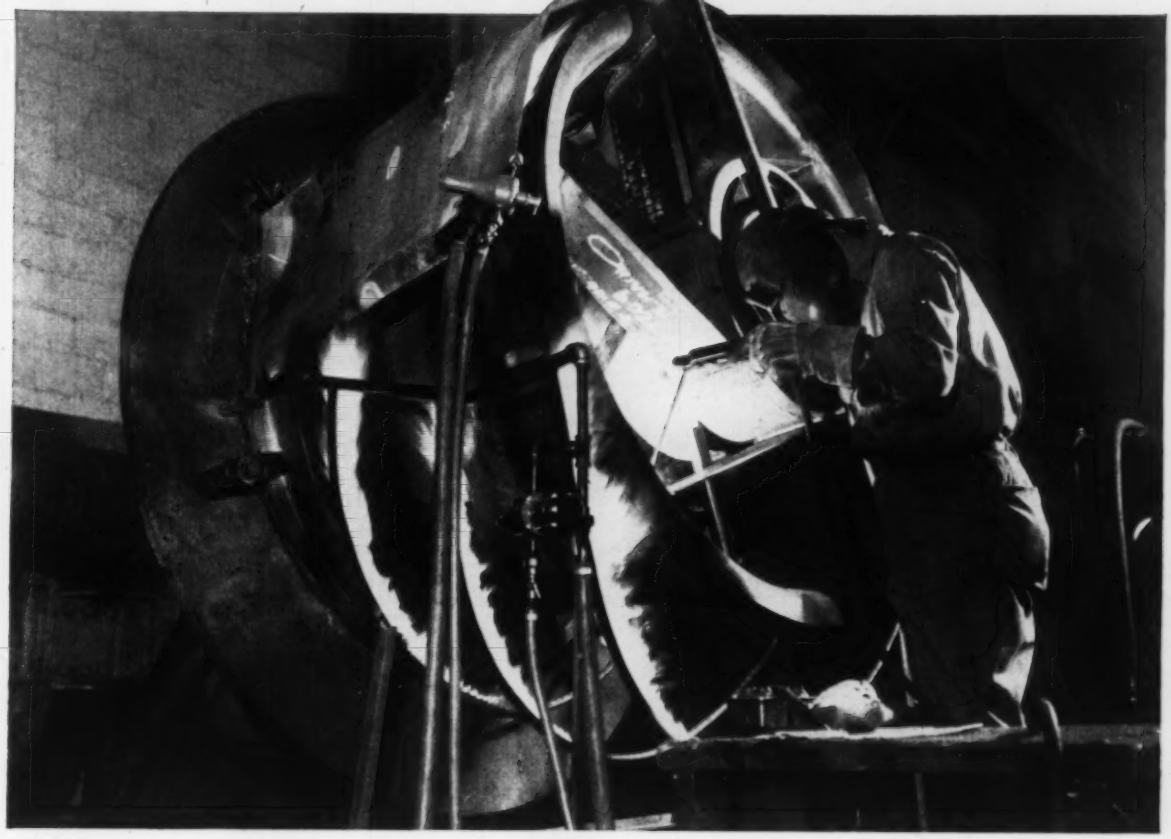
Can your product be made more efficient with Beaver Ball Screws?

Write for information.

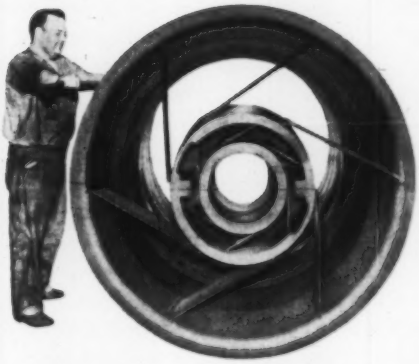
Beaver Precision Products INC.
CLAWSON, MICH.

Circle 543 on Page 19

STEEL-WELD FABRICATION . . .



Industrial GAS TURBINE Housings!



MACHINED WELDMENT

The gas turbine housing illustrated here is one of many produced and machined by the Mahon Company. Steel-Weld Fabrication of special alloy steel components for use in precision manufacture of gas turbines requires craftsmanship and control know-how.

When you consider the use of welded steel components in the design of processing machinery, machine tools or other types of heavy mechanical equipment, you, too, will want to discuss your requirements with Mahon engineers; because, in the Mahon organization you will find a unique source for weldments or welded steel in any form . . . a fully responsible source with a long and enviable performance record, and unusual facilities for design engineering, fabricating, machining and assembling.

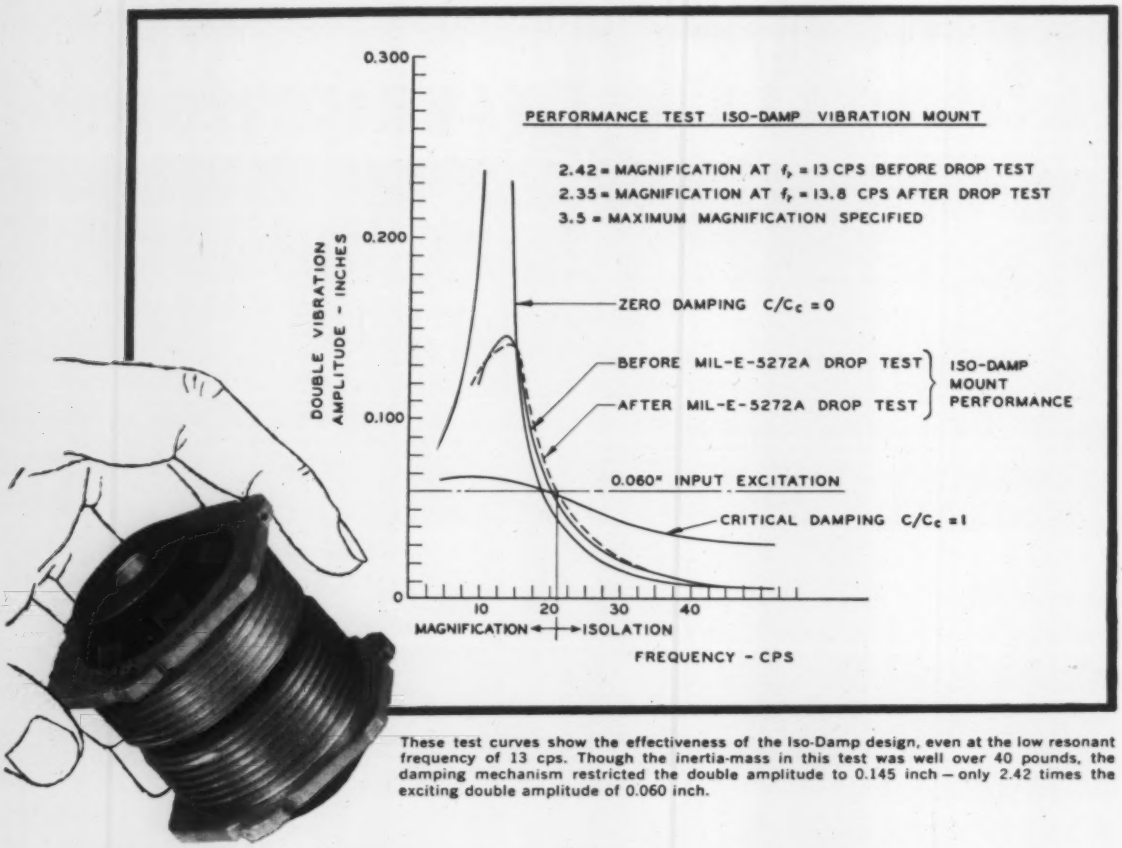
See Sweet's Product Design File for information, or have a Mahon sales engineer call at your convenience.

THE R. C. MAHON COMPANY · Detroit 34, Michigan

SALES-ENGINEERING OFFICES in DETROIT, NEW YORK and CHICAGO

MAHON

Circle 544 on Page 19



These test curves show the effectiveness of the Iso-Damp design, even at the low resonant frequency of 13 cps. Though the inertia-mass in this test was well over 40 pounds, the damping mechanism restricted the double amplitude to 0.145 inch – only 2.42 times the exciting double amplitude of 0.060 inch.

MB Iso-Damp™ mounts give full frequency vibration control

A MOUNT soft enough to isolate vibration in the upper range of operating frequencies generally gives trouble when there's a low natural frequency present. It causes resonant build-up... magnifies the motion, as shown by the curve above. Not so the MB Iso-Damp mount. It works at *both* ends of the frequency spectrum... and in any position.

Resilient rubber sections with equal spring rates in all directions (an original MB mount principle) give high frequency isolation efficiency in any position. In the low range, resonance is restricted by a unique damping mechanism to well below a 3½ to 1 build-up. The mechanism does not affect high frequency isolation.

Iso-Damp mounts can be modified to special equipment requirements. They're available in a number of sizes, in threaded or press-in types. When assembled, the damping mechanism is totally enclosed and protected. Load capacities range from 15 to 100 pounds per mount.

MB concentrates on standard mounts which are actually in the *special performance* class. If you have a problem, lean on our 20 years of vibration experience. Send for Bulletin 616A which tells more.

MB manufacturing company 1056 State Street New Haven 11, Conn.

A Division of Textron Inc.

HEADQUARTERS FOR PRODUCTS TO ISOLATE VIBRATION...TO EXCITE IT...TO MEASURE IT.

at either top or bottom. Receptacle can be mounted on its base or on either side, with conduit opening at top or bottom. Combined with reversible plug-in unit, this provides six different mounting arrangements. Switch action can be reversed by screwdriver adjustment. Switch requires only 5 deg to operate, provides for 25-deg overtravel. **Square D Co.**, 4041 N. Richards St., Milwaukee 12, Wis. K

Circle 726 on Page 19

Adhesive

bonds synthetic elastomers to metals, fabrics, and plastics

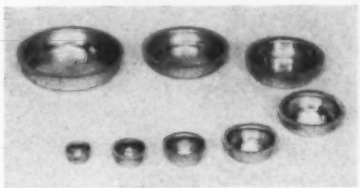
Chemlok 607 is a clear, colorless liquid adhesive for bonding unvulcanized silicone and other synthetic elastomers, including Viton A, to steel, copper, brass, aluminum, titanium, magnesium, chrome-plated steel, fabrics, and plastics of many types. It provides excellent adhesion, and has a variety of applications where a superior bond is required. Adhesive can also be used successfully to bond Viton A to Dacron and glass fabrics. **Special Products Div., Lord Mfg. Co.**, 1635 W. 12th St., Erie, Pa. F

Circle 727 on Page 19

Aluminum Plugs

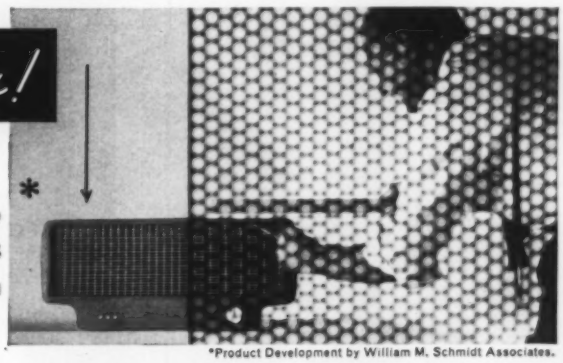
in pipe sizes from 1/8 to 3 in.

Soft aluminum plugs are designed for internal thread protection, as



Idea!

mock-up projects design



*Product Development by William M. Schmidt Associates.

with H & K perforated metals

A few of the thousands of H & K patterns are illustrated in reduced size

Send today to nearest H & K office for General Catalog

Here is an H & K perforated metal grille utilized in a mock-up of a record player. This greatly helps the Industrial Designer project his concepts as H & K perforated metal is now in its proper element for consideration of use and selection of pattern.

By referring to the H & K General Catalog, the designer can select one or more patterns for his project.

H & K perforated metals provide the Industrial Designer, and other men of ideas, a medium of unlimited opportunities for designing better and more attractive products.

THE Harrington & King PERFORATING CO. INC.

Chicago Office and Warehouse • 5670 Fillmore Street • Chicago 44, Illinois

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Circle 546 on Page 19

No Chippage when you use Sicon® SILICONE HEAT RESISTANT FINISH

PROVED by over 25,000 TEMCO Wall Heater Installations

The upper grille of this handsome TEMCO Gas Wall Heater is finished with 7x7070 Brown SICON Silicone-Base Heat Resistant Finish. The number of louvers on this upper grille presented a chippage problem with vitreous enamel which prompted Temco to turn to SICON. Normal operating temperatures run about 350° F. but the temperature encountered on blocked flue conditions require a heat resistant finish to withstand 500° F...SICON 7x7070 Brown, on 25,000 or more Temco installations, has successfully met field performance requirements without loss of color, gloss or adhesion. Investigate other case histories of SICON—the remarkable finish that has solved over 150 heat resistant finish problems! Write today!

Sicon®

The Original Silicone Base Heat Resistant Finish

MIDLAND Industrial Finishes Co.

Waukegan, Illinois Dept. F-9

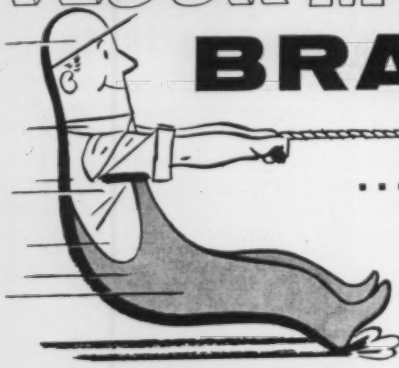
ENAMELS • SYNTHETICS

LACQUERS • VARNISHES

Circle 547 on Page 19

Stearns ELECTRO-MAGNETIC DISC

FLOOR MOUNTED BRAKES



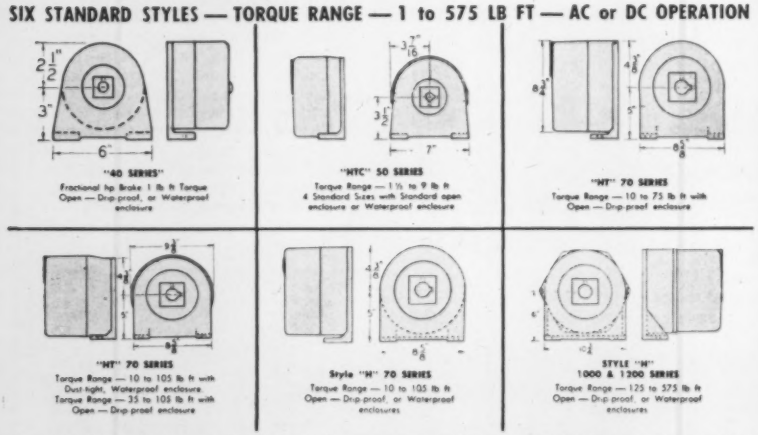
...quietly stop individual shafts or motors—fast

...and keep both feet on the ground!

Stearns Style "H"—70 Series Floor Mounted Brake. One of 6 Styles shown below.

- For fast, direct attachment to shafts, or "double-end" electric motors that you have on hand . . . no couplings required.
- For local, manual — or remote, automatic, or pushbutton control.
- For economy — smaller, less costly brakes can be used for stopping individual shafts.
- For superior performance . . . Specify Stearns . . . the brakes with exclusive "Visi-Indicators" for wear . . . and longest, dependable, trouble-free, quiet operation.

SIX STANDARD STYLES — TORQUE RANGE — 1 to 575 LB FT — AC or DC OPERATION


"40 SERIES"
Fractional hp Brake 1 lb ft Torque
Open — Drip-proof, or Waterproof enclosure
"HTC" 50 SERIES
Torque Range — 1½ to 9 lb ft
4 Standard Sizes with Standard open enclosure or Waterproof enclosure
"HT" 70 SERIES
Torque Range — 10 to 75 lb ft with Open — Drip-proof enclosure
"HT" 70 SERIES
Torque Range — 10 to 105 lb ft with Dust-tight, Waterproof enclosure
Torque Range — 35 to 105 lb ft with Open — Drip-proof enclosure
Style "H" 70 SERIES
Torque Range — 10 to 105 lb ft
Open — Drip-proof, or Waterproof enclosures
STYLE "H"
1000 & 1200 SERIES
Torque Range — 125 to 575 lb ft
Open — Drip-proof, or Waterproof enclosures

For practical solutions to YOUR starting-stopping problems call the Stearns Representative in your vicinity. Or write stating your specific requirements, directly to . . .

Stearns ELECTRIC CORPORATION
120 NORTH BROADWAY
MILWAUKEE 2, WISCONSIN

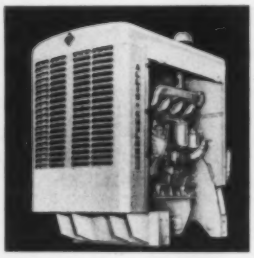
hole plugs, for protection of ground, polished, plated, or painted internal surfaces, for temporary sealing of valve seats, tubes, and tube fittings, for sealing in oil, grease, and rust-proofing compounds for shipping, and for masking surfaces during finishing operations. The protectors are available in pipe-size increments from $\frac{1}{8}$ to 3 in. Softness of the metal guarantees that thread will not be damaged during application or removal of plugs. **Protector Products Inc.**, 2156 W. 15th St., Cleveland 13, Ohio. G

Circle 728 on Page 19

Diesel Engines

for heavy-duty, general-purpose use

Two new 88 and 131-hp diesel power units serve a wide range of power requirements in fields where heavy-duty, general-utility units are adaptable. The high-torque engines provide a steady horsepower output at working speeds from 1000 to 1800



rpm. The 88-hp model is a four-cylinder unit and the 131-hp model (shown) a six-cylinder unit. Follow-through combustion system with low peak pressures and simplicity of design assures fuel economy and low operating cost. Other features include 24-v electrical starter and generator, a single-plunger, dustproof, self-lubricating fuel injection pump, and large-capacity fuel filters. Both units are available in either closed or open models. **Engine-Material Handling Div., Allis-Chalmers Mfg. Co.**, Milwaukee, Wis. K

Circle 729 on Page 19

Miniature Servo

produces high torque output

Model 100-1 miniature servo, designed primarily for servo repeater applications, meets the needs for an

• less wear on runways...

• longer life for chain

JEFFREY BARLOOP CHAIN

Interchangeable with your flat-and-round chain. It is inexpensive and long-lived.

Jeffrey barloop chain presents low bearing pressures to surfaces on which it slides. Serves well in handling of non-abrasive or semi-abrasive materials because the open strap construction makes it self-cleaning. No trapping of corrosive, abrasive materials being handled by the conveyor to accelerate pin wear.

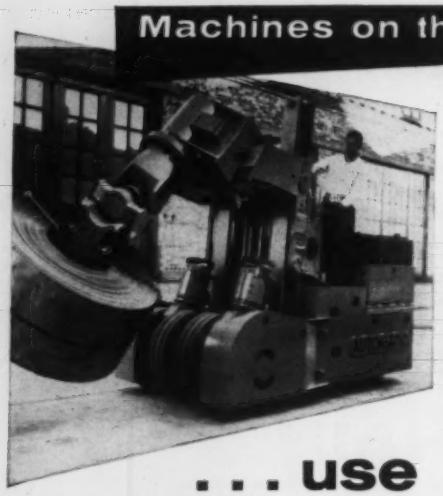
Installing and modification of conveyors are simplified with Jeffrey barloop chain. It can easily be taken apart and put together at any point. There's less downtime for conveyor upkeep.

Ask your nearby Jeffrey distributor about Jeffrey barloop chain for general elevator and conveyor service. He can advise on and take care of most of your chain requirements. The Jeffrey Manufacturing Company, 798 North Fourth Street, Columbus 16, Ohio.

JEFFREY

CONVEYING•PROCESSING•MINING EQUIPMENT...TRANSMISSION MACHINERY...CONTRACT MANUFACTURING

Machines on the move . . . . .



. . . use

FAIRFIELD GEARS!

POWER to operate these machines and countless others that you may see every day, travels *smoothly, efficiently, dependably* through FAIRFIELD GEARS. By specializing exclusively in "Fine Gears Made to Order", Fairfield has become one of America's largest independent producers of these parts.

If you use gears in the product you make, we believe it will pay you, as it has others, to become acquainted with FAIRFIELD—the place where fine gears are produced to meet your specifications EFFICIENTLY, ECONOMICALLY! Fairfield's production facilities are unexcelled. *Call or Write.*

FAIRFIELD MANUFACTURING CO.

2307 South Concord Road • Lafayette, Indiana
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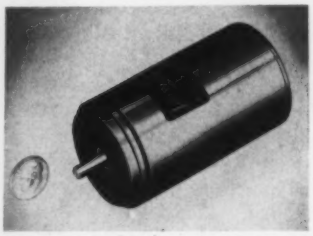
A "PLUS VALUE" IN ANY PRODUCT

Gears and Differentials For FINE GEARS *Made to Order for:*

TRACTORS • HEAVY DUTY TRUCKS • AGRICULTURAL MACHINERY • POWER SHOVELS AND CRANES
MINING MACHINES • ROAD GRADERS • BUSES • STREET SWEEPERS • INDUSTRIAL LIFT TRUCKS



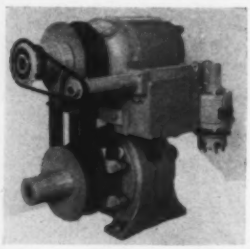
isolation servo between synchro components, or a synchro-controlled servo drive for resolvers, potentiometer, or shaft-to-digital converters. Unit is light in weight, compact, and has high sensitivity to synchro input, producing high torque output. It is designed to Mil-E-5400 specifications. Servo, which is built within a package 3 in. long and 1¼ in. in diameter, includes motor, control transformer, amplifier, gear train, and related circuitry. Power requirements are 115 v ac 400 cps and 28 v dc. **Librascope Inc.**, 808 Western Ave., Glendale 1, Calif. L

Circle 730 on Page 19

Remote Speed Control

is pushbutton controlled

New electric remote speed control provides for varying machine speeds from a convenient location. Control is used with Lewellen combination pulleys. It is mounted next to the pulley-driving motor, either on the machine or on the floor,



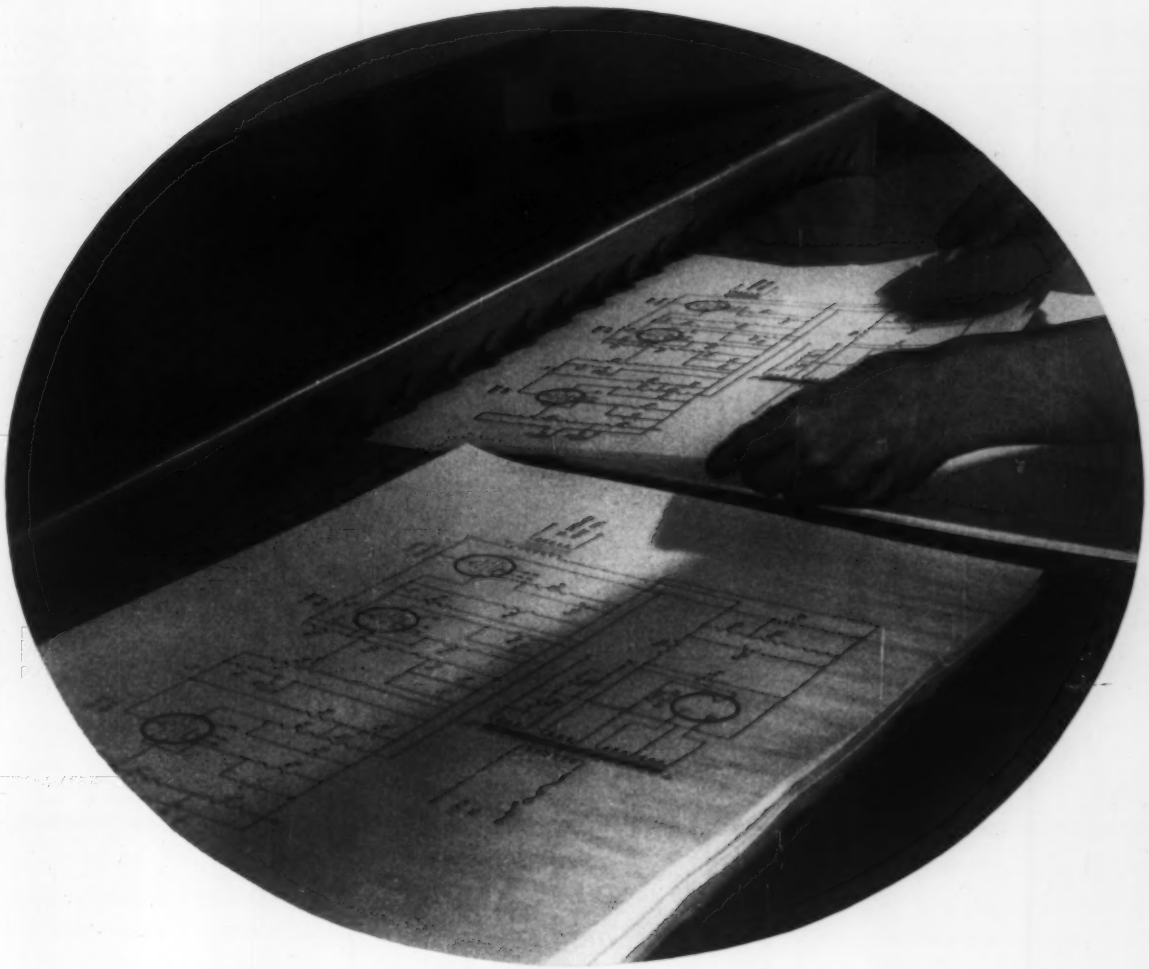
and drives to the adjustable-speed pulley by roller chain. Unit is pushbutton controlled, and limit switches set fastest and slowest speeds. **Lewellen Mfg. Co.**, 1428 10th St., Columbus, Ind. J

Circle 731 on Page 19

Rubber-Casting Material

combines hardness, toughness, and resilience

ElastaCAST liquid urethane rubber is a casting material for use



Cronaflex is durable:

TRADEMARK

Same "second original" makes hundreds of exact copies

The CRONAFLEX "second original" in the picture has already reproduced over a hundred clear, black-line copies. It's good for hundreds more. CRONAFLEX shrugs off kinks and wrinkles, no matter how many times it's passed through a reproduction machine.

The CRONAFLEX matte surface provides the finest pencil and ink acceptance. Lines never smudge. They can be drawn—or erased and redrawn—on either side of the film. You make your corrections right on the CRONAFLEX; your valuable original drawing remains untouched.

CRONAFLEX Engineering Reproduction Films are available in three types: (1) Direct Positive Film, (2) Contact Film and (3) Projection Film. For more information on this revolutionary new line, write: E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont Company of Canada (1956) Limited, Toronto.

This advertisement was prepared exclusively by Phototypography

DU PONT
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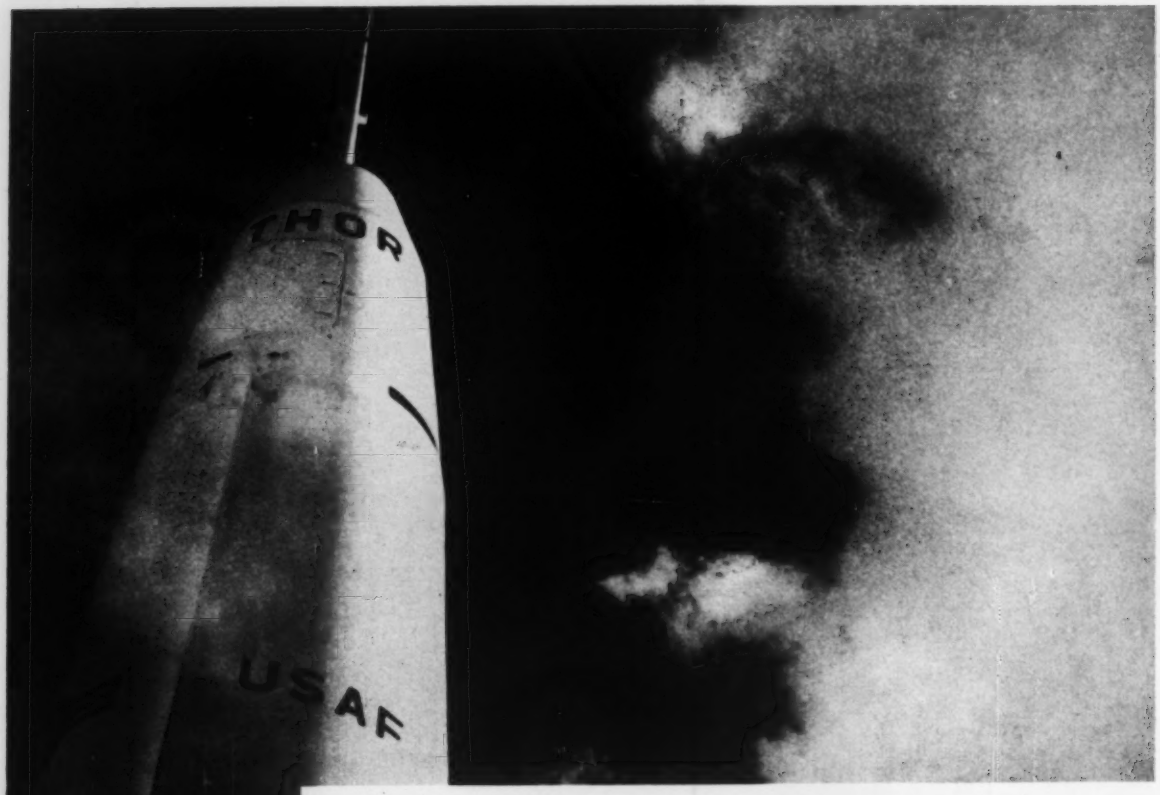
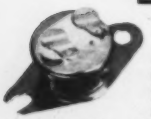
Better Things for Better Living . . . *through Chemistry*



KLIXON THERMOSTATS

help assure reliability of

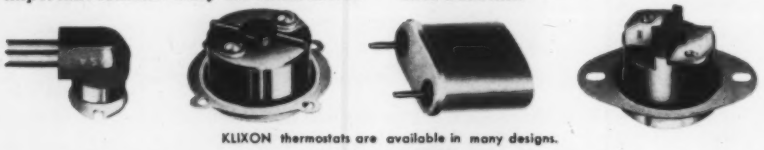
BALLISTIC MISSILES



Among the hundreds of vital parts required for ballistic missiles are several KLIXON Hermetically Sealed Thermostats. Spencer Division supplies thermostats to the General Electric Company's Missile and Ordnance Systems Department, developers of the nose cone for the Air Force's THOR IRBM.

KLIXON snap-acting controls are ideal for applications of this type — for several important reasons. They are small in size and light in weight; they respond to temperature change quickly and with accurate repeat performance; they have ample capacity to handle heavy electrical loads; and their calibrations stand up in the face of severe environmental conditions.

That is why more and more manufacturers of all kinds of equipment choose KLIXON controls with confidence — why you, too, should investigate the KLIXON line for application possibilities in your products. Write today for THSN technical data bulletins.



KLIXON thermostats are available in many designs.

METALS & CONTROLS CORPORATION

Spencer Division 3206 Forest Street, Attleboro, Mass.

KLIXON®

in industrial parts where high load-bearing and long wearing properties are required. Material, which possesses excellent abrasion resistance and high tensile strength, combines hardness, toughness, and resilience. Parts of unusual shapes, contours, and sharp radii without limitations in size can be produced. Material can be bonded to metal, and used with or bonded to rigid inserts to provide inexpensive gears, wheels, rollers, and platens. It is available in standard formulations covering a wide range of hardness from 62 to 95 Shore A, with tensile strengths of 4200 to 7300 psi, and ultimate elongation values of over 500 per cent. Material has many applications because of its excellent abrasion and tear resistance, good rebound elasticity, excellent resistance to ozone, solvents, sunlight aging, and oxidation. **Acushnet Process Co.**, New Bedford, Mass. B

Circle 732 on Page 19

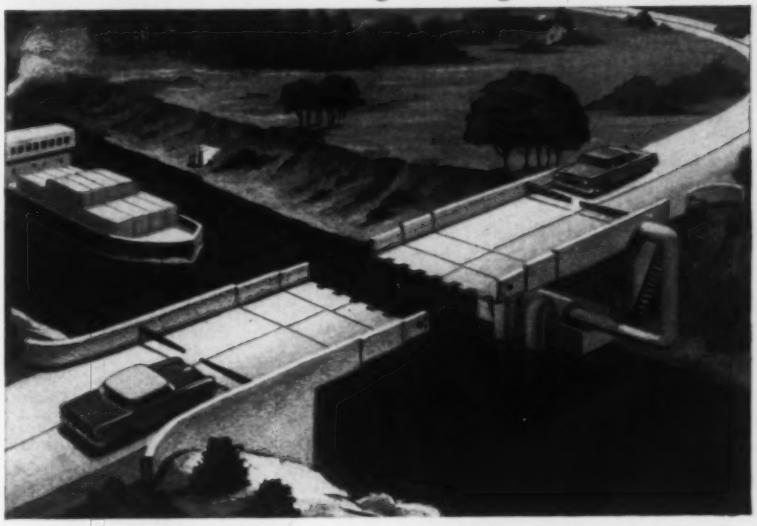
Speed Governor

has torque capacity of 30 lb-in. at 1200 rpm

Type 2300 small mechanical flyball type governor is capable of accurate speed regulation. It is used as the main speed control on small engines and as an over-speed governor on larger engines. Other applications are on diesel and gasoline engines, on steam turbines in services varying from pumps and compressors to electric generating sets, for marine use, and where service conditions require an adjustable-speed governor. Torque capacity is 30 lb-in. at 1200 rpm. Constant-speed range is 500 to 2400 rpm, and adjustable-speed range is 500 to 1440 rpm. **Farris Pickering Governor Co. Inc.**, 702 Commercial Ave., Palisades Park, N. J. D

Circle 733 on Page 19

MARS outstanding design **SERIES**



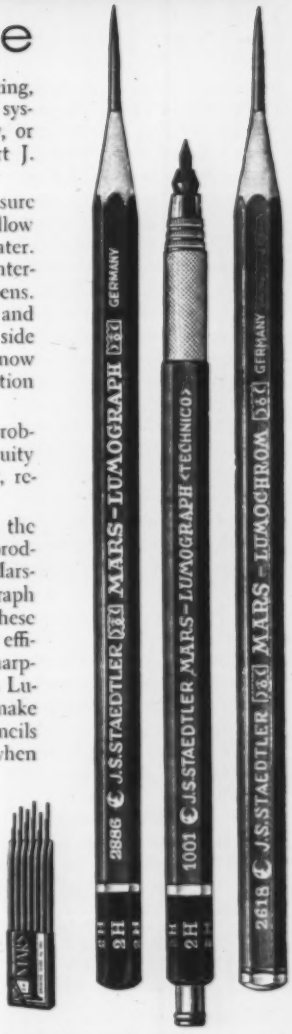
automated bridge

The bridge of tomorrow will be self-activating, equipped with electric-eye controls and an anti-freeze system. No overhead structures will obstruct the view, or interfere with radio reception, according to Robert J. Companik of Chicago.

In his design, the bridge is operated by pressure pumps that draw water from the canal into the hollow structure and hold it shut by the weight of the water. To allow boats to pass, pressure is released, counterweights pull the sections together, and the bridge opens. An electric eye down the canal activates the opening and the bridge does not close until an eye on the other side is passed. Heating units keep both eyes free from snow and ice, and a brine system keeps the bridge in operation in freezing weather.

Many ingenious solutions to traffic and other problems are on the boards today. To make their ingenuity clear, and to translate them from idea into reality, requires the best of drafting tools.

In pencils, of course, that means Mars, long the standard of professionals. Some outstanding new products have recently been added to the famous line of Mars-Technico push-button holders and leads, Lumograph pencils, and Tradition-Aquarell painting pencils. These include the Mars Pocket-Technico for field use; the efficient Mars lead sharpener and "Draftsman" pencil sharpener with the adjustable point-length feature; Mars Lumochrom, the color-drafting pencils and leads that make color-coding possible; the new Mars Non-Print pencils and leads that "drop out" your notes and sketches when drawings are reproduced.



The 2886 Mars-Lumograph drawing pencil, 19 degrees, EXEXB to 9H. The 1001 Mars-Technico push-button lead holder. 1904 Mars-Lumograph imported leads, 18 degrees, EXB to 9H. Mars-Lumochrom color-drafting pencil, 24 colors.

J.S. STAEDTLER, INC.
HACKENSACK, NEW JERSEY

at all good engineering and drawing material suppliers

Circle 553 on Page 19

4 Ounce Contact Force Makes Relays More Reliable

Contact force of 4 ounces per contact on 50 "G" models and 2 ounces per contact on 30 "G" models of "Diamond H" Series R and Series S miniature, hermetically sealed, aircraft type relays is one of the most important factors in their proven high reliability.

Though absolute reliability of any similar device is impossible to guarantee—a bitter fact of life recognized by all electronic engineers—close approach to this goal by the relays manufactured by The Hart Manufacturing Company is the basic reason they are found today on many of this country's headline-making missiles.

In addition to contact force far beyond that found on other relays, "Diamond H" relays have greater contact cleanliness. Self-contamination is virtually eliminated by a completely inorganic switch mechanism, as well as use of coil materials which will not dust, flake or out-gas.

Finally, the high degree of reliability that is designed into these relays is maintained in their manufacture by high quality workmanship and a stringent inspection policy at every stage.

In addition to missiles, and their ground control systems, Series R and S relays are designed for use in jet engine controls, computers, fire control, radar and similar critical applications.

4PDT units, they offer an extremely broad range of performance characteristics, including temperature ranges from —65° C. to 125° and 200° C.; ratings to 10 A., 120 V., A. C., and 26½ V., D. C., with special ratings to 400 ma. at 350 V., D. C., or down to millivolts and milliamperes. Dry and wet circuits may be safely inter-mixed.

For more information, write today for Bulletins R250 and S260. For quick facts about "Diamond H" switches, thermostats and other devices, ask also for a copy of the "Diamond H" Check List of Reliable Controls.

THE **HART** MANUFACTURING COMPANY

118 Bartholomew Ave., Hartford 1, Conn.
Phone JAckson 5-3491

Circle 554 on Page 19

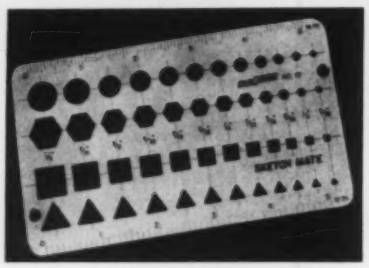
ENGINEERING DEPARTMENT

EQUIPMENT

Template

contains circles, squares, hexagons, and triangles

No. 19 Sketch Mate template contains circles, hexagons, squares, and triangles grouped for ease in sketching and layout in all design fields. Cut-outs range from 3/32 to ½ in.,



with increments of 1/32 in. to the ⅜ in. size, and 16ths thereafter. Unit has two 5-in. scales, one graduated in 10ths and the other in 16ths. Template is 0.030 mathematical-quality plastic with matte finish. Over-all size is 5¾ x 3¼ in. **Rapidesign Inc.**, P. O. Box 429, Burbank, Calif. L

Circle 734 on Page 19

Analog-Digital Converter

doubles as digital voltmeter

Voldicon, designed to operate either as a digital voltmeter or an analog-to-digital converter, is capable of 2000 completely independent conversions per sec. It is completely transistorized to eliminate noise and heat and to reduce maintenance to a minimum. Use of transistors eliminates relays, vacuum tubes, and stepping switches. The converter is completely synchronous. After it has made one conversion it is ready to make another when commanded by an external trigger. When used as an analog-to-digital converter, unit can be incorporated into almost any system because of variety of outputs provided. Con-

For LINEAR AND ROTARY POSITIONING

Specify LimiTorque ACTUATORS

LimiTorque actuators are efficient, sensitive, automatic heavy duty power-operated units for positioning machine parts or other assemblies requiring Linear or Rotary Motion.

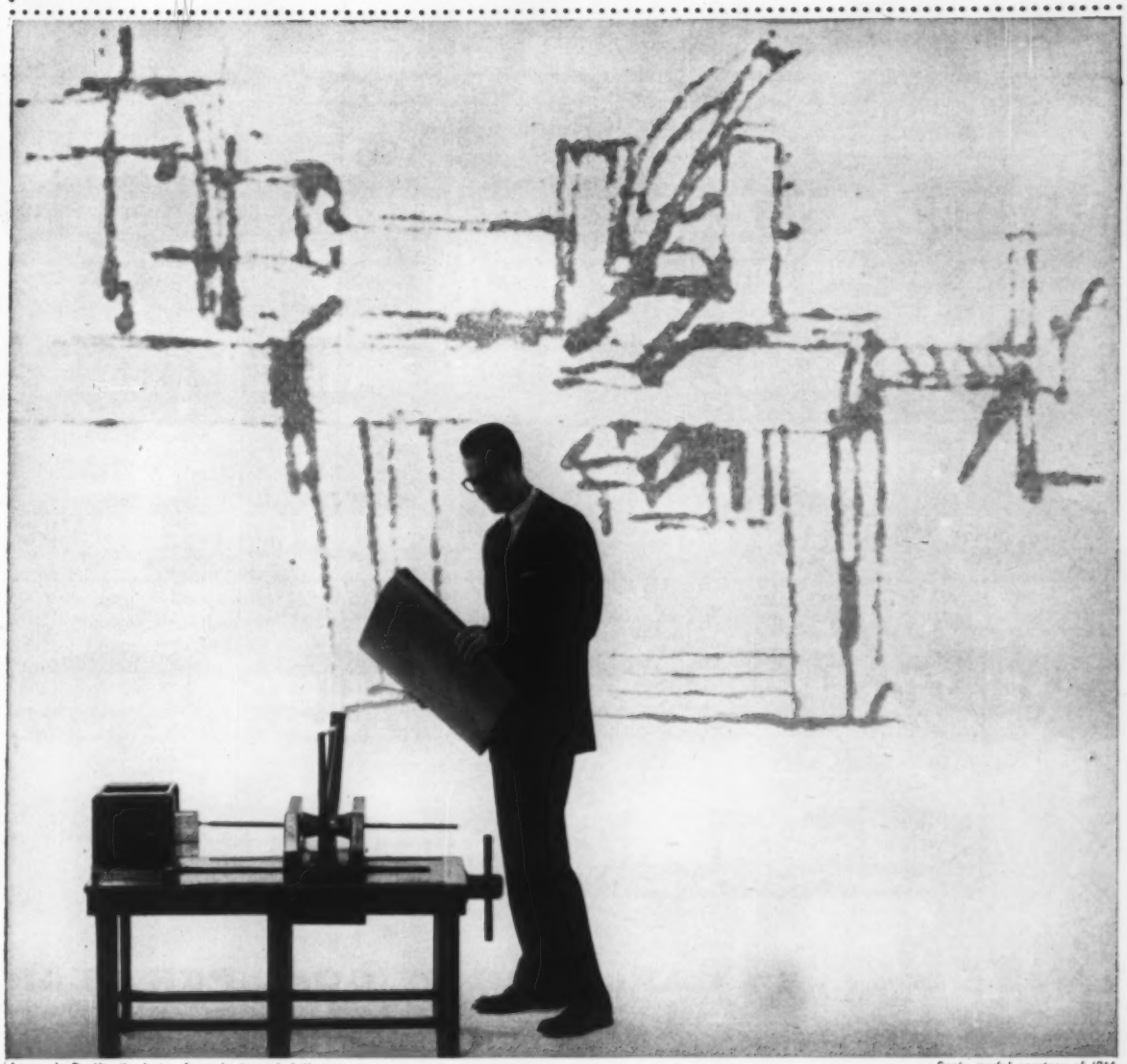
LimiTorque is an electro-mechanical mechanism, using motor power through highly efficient and precision gearing, to impart Linear or Rotary motion . . . Limit switches are available to limit the travel in either direction—Thrust and Torque responsive switches control thrust or provide emergency shut-off. With LimiTorque it is possible to control full travel accuracy to within .2%—LimiTorque is easily and accurately controlled by the mere "push of a button".

LIMITORQUE IS BACKED BY 30 YEARS' EXPERIENCE IN MOTORIZING ALL TYPES OF VALVES—WHY NOT CONSULT US REGARDING ANY PROBLEM YOU MAY HAVE INVOLVING LINEAR ACTUATION; OUR ENGINEERS CAN NO DOUBT HELP YOU SOLVE THAT PROBLEM.

LimiTorque
PHILADELPHIA GEAR CORPORATION
ERIE AVE. & G STREET, PHILADELPHIA 34, PENNA.
Offices in all Principal Cities
INDUSTRIAL GEARS & SPEED REDUCERS
LIMITORQUE VALVE CONTROLS
FLUID MIXERS • FLEXIBLE COUPLINGS

Circle 555 on Page 19

creative designing calls for an open mind



Leonardo Da Vinci's design for a horizontal drill press. *Scale model courtesy of IBM*

EVEN DA VINCI'S HORIZONTAL DRILL PRESS COULD HAVE BEEN BETTER WITH HELP FROM AN SKF ENGINEER.

Designs improve with help from an SKF engineer because his line covers all four types of ball and roller bearings in many thousands of sizes. In no way are his recommendations confined by his product line. Quite the contrary. He has the kind of flexibility he requires to keep an entirely open mind on any bearing problem. Give your problem to SKF and see.

7843

Spherical, Cylindrical, Ball, and "Tyson" *Tapered Roller Bearings*

EVERY TYPE—EVERY USE

SKF®

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

*REG. U. S. PAT. OFF.

SAVED... 34 CARLOADS OF COAL PER YEAR

...BY THE USE OF NEW COLD BONDERITE SYSTEM

That's the way one plant figures it. 1700 tons of coal saved per year because the Cold Bonderite System cuts steam requirements for the phosphating line by as much as 70%.

Have you asked the Parker man about the new Cold Bonderite System for your phosphating line? There's no reason for you to go on paying high steam costs when this new low temperature combination produces high quality results with real economy.

Your request for information on the new Cold Bonderite System will get high priority from us. Write, call or wire today.

Since 1914— leader in the field

PARKER

RUST PROOF COMPANY
2193 Milwaukee, Detroit 11, Michigan
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BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

verter permits choosing of code by pulling slides on which matrix is mounted and changing jumpers. Printed-circuit cards, designed to prevent error, can be inserted only in correct location in unit. **Adage Inc.**, Dept. P, 292 Main St., Cambridge, Mass. B

Circle 735 on Page 19

DC Power Supplies

have modular mounting design

Models RS-217A and RS-317 power supplies are for use in laboratory, test bench, or original equipment applications. Furnished with modular mounting design, the two models are similar except for output voltage ranges. Output for Model RS-317 (shown) is 225-325 v dc at 175 ma continuous duty, and for

RS-217A, 150-225 v dc at 175 ma. Input of both models is 105-125 v, 60 cps ac, line regulation is 0.1 per cent, load regulation is 0.1 per cent, and noise is less than 7 mv. Units are available for chassis or rack mounting. **Trans Electronics Inc.**, 7349 Canoga Ave., Canoga Park, Calif. L

Circle 736 on Page 19

Two-Channel Oscillograph

has high chart speed of 625 and 1250 mm per sec

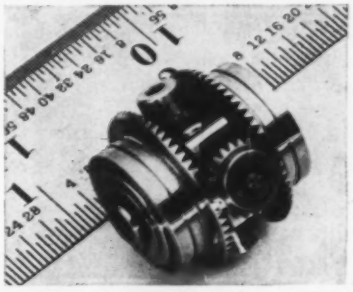
Two-channel direct-writing oscillograph, designated RD 2322 10, is suitable for both general-purpose and high chart speed recording. Unit has five chart speeds of 5, 25,

MICRO-BEARING ABSTRACTS

by **A. N. DANIELS**, *President*
New Hampshire Ball Bearings, Inc.

MINIATURE BEARINGS AND GEAR DIFFERENTIAL BACKLASH

(NOTE: We are grateful to W. J. Opocensky, Staff Engineer, Librascope, Inc., Glendale, California, for his factual report on the part played by our bearings in the design of the small two-pinion differential illustrated below.)



LIBRASCOPE 3/16" HOLLOW SHAFT DIFFERENTIAL uses special duplex MICRO-BEARINGS in all gears. Specifications are: Working circle 1.090", Length .980"; Input gear hole size .687", Starting torque .2 in. oz. — Maximum backlash 5 min. at 2 in. oz.

Miniaturization of precision ball bearings and gears is well advanced. However, putting them together to produce a small differential with low torque and backlash of five minutes or less is no simple task. Loads on single pinion differentials and on single ball bearings introduce objectionable flexibility. So does uncontrolled radial play in ball bearings whether used singly or in pairs.

After considering many designs, Librascope selected a two-pinion differential as the most logical type to develop. A "hunting tooth" gear ratio was also chosen to distribute wear evenly. Double bearings preloaded were to be used in all gears.

Special miniature bearings were developed to give duplex bearing performance at a cost only slightly higher than regular catalog prices.

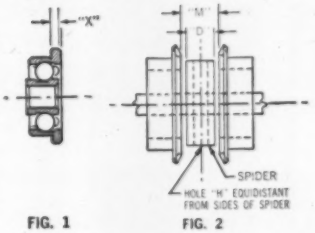


FIG. 1 FIG. 2

Dimension "X" in *Fig. 1* is coded in increments of .0002" under given axial load.

In *Fig. 2* the mounting distance "M" of the bevel gears is known. With the new bearing dimension "X" it is possible to determine the "spider" dimension "D". This provides the desirable mounting distance of bevel gears without shims.

To obtain maximum distance between raceways in limited space, narrow unshielded bearings were selected. To provide dust protection for the bearing a thin shim slightly smaller than the I. D. of the outer bearing race is used between bearing and Truarc ring. Truarcs are stainless steel double-disc-ground to various specific dimensions. With all dimensions controlled, bevel gears are accurately located from the pinion shaft hole, and any desired preload in the bearing can be obtained by selecting a Truarc of proper thickness.

Control of radial play of bearings in pinions presented a different, though similar, problem. Space limitations in the pinion are much more severe than with bevel gears. *Fig. 3* shows how Librascope solved the problem. Dimension "X" is coded in increments of .0001" with a given axial load, from inner race to outer race opposite the flange side on the one hand and opposite the ball retainer side on the other. A precision shim is used between outer races of the two bearings. By selection and use of new coded dimensions, any desired preload of bearings is obtained by fitting bearings to the shim.

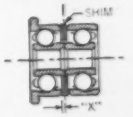


FIG. 3

To keep bearing races in mutual contact, another novel idea is used. Each pinion has its own adjustable shaft. The outside end of the pinion shaft is fitted with a Truarc. This rests against inner race of outside bearing. To overcome the limited adjustment of shims and expensive labor costs, a unique adjustable washer is used. By means of a special tool, each pinion may be adjusted for any desired amount of backlash. Bearings are held at preload by adjustable washer and Truarc. A clamping means secures pinion shaft to "spider".

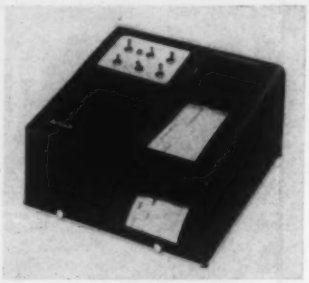
The Librascope differential design makes possible "5 minute" differentials at 2 in. oz. loads. Measurements are taken at *eight* equally spaced positions for one full turn of the "spider". The maximum backlash recorded determines classification of differential.

DESIGN HANDBOOK OFFERED FREE

You'll find this 70-page authoritative publication helpful in solving problems in designing instruments of small electromechanical assemblies. Write:

NEW HAMPSHIRE BALL BEARINGS, INC., PETERBOROUGH 1, NEW HAMPSHIRE

Circle 558 on Page 19



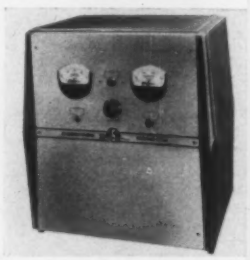
125, 625, and 1250 mm per sec. Design provides for instantaneous selection of higher chart speeds by spring-loaded switches which, on release, automatically return chart movement to preset conventional speed. Oscillograph is equipped to write on inexpensive, reproducible charts with ink, or on electrosensitive charts with electric writing. Charts have wide application in research, design, and production. **Brush Instruments, Div., Clevite Corp.**, 3405 Perkins Ave., Cleveland 14, Ohio. G

Circle 737 on Page 19

Power Supply

has 4000-w capacity

Model MA28-125 dc power supply feeds systems drawing up to 125 amp at 18 to 36 v dc. It provides tubeless operation based on a magnetic amplifier control circuit with transistorized power reference and zener diode comparison circuit. Unit has capacity of 4000 w of controlled power. Both rack and cabinet models are available. Specifications include 208, 230, or 460-v three-phase, 60-cycle input; ±0.1 per cent typical



regulation accuracy; 1 per cent maximum ripple; less than 0.1 sec response time. Use of transistors, silicon rectifiers, and high-temperature wound components makes the supply small and light. **Sorensen & Co. Inc.**, Richards Avenue, South Norwalk, Conn. B

Circle 738 on Page 19

Specify

THOMAS

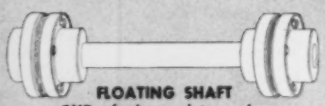
ALL METAL

FLEXIBLE COUPLINGS

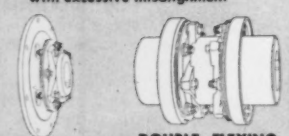
FOR MAINTENANCE FREE POWER TRANSMISSION on PUMP, COMPRESSOR, MARINE and OTHER DRIVES

DBZ — for high speed, heavy duty drives

Thomas' 40 years of flexible coupling experience is at your disposal to help you meet ordinary applications or special variations for unusual cases.



FLOATING SHAFT
BMR — for heavy duty service with excessive misalignment



SINGLE FLEXING
SS — for engine-driven generator sets with out-board bearings

DOUBLE FLEXING
AMR — for engine and medium speed drives

UNDER LOAD and MISALIGNMENT ONLY THOMAS FLEXIBLE COUPLINGS OFFER ALL THESE ADVANTAGES.

1 Freedom from Backlash Torsional Rigidity
2 Free End Float
3 Smooth Continuous Drive with Constant Rotational Velocity
4 Visual Inspection While in Operation
5 Original Balance for Life
6 No Lubrication
7 No Wearing Parts
8 No Maintenance

Write for Engineering Catalog

THOMAS FLEXIBLE COUPLING CO.

WARREN, PENNSYLVANIA, U. S. A.

Circle 559 on Page 19

Somers

METALLIC TAPES for INDUSTRY

For recording, electronic computing and other applications where close tolerance, controlled surface (less than 10 microinches), burr-free slit edge and maximum continuous length are essential, SOMERS quality metallic tapes are a must.

Currently being produced are Nickel, Copper and alloys including Monel, Inconel, Brass, Phosphor Bronze and Nickel Silver and Stainless Steel. Gauges range from .000175" to .010" and widths from ⅛" to 25" depending on thickness.

Whatever your strip problem may be, you'll find satisfaction with SOMERS THIN STRIP. Write for confidential data blank or field engineer.

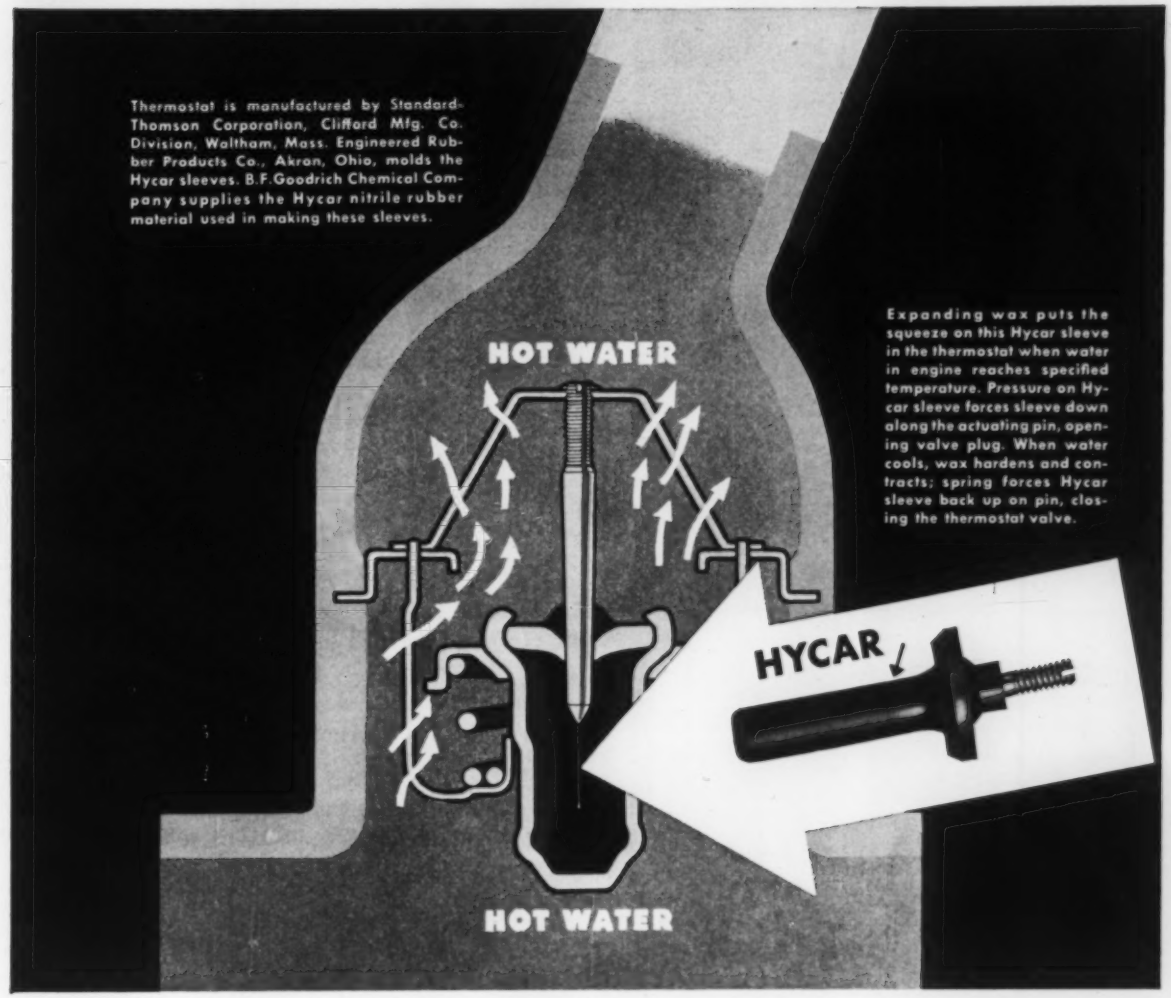
Somers Brass Company, Inc.

120 BALDWIN AVE., WATERBURY, CONN.

Circle 560 on Page 19

Another new development using

B.F.Goodrich Chemical *raw materials*


Thermostat is manufactured by Standard-Thomson Corporation, Clifford Mfg. Co. Division, Waltham, Mass. Engineered Rubber Products Co., Akron, Ohio, molds the Hycar sleeves. B.F.Goodrich Chemical Company supplies the Hycar nitrile rubber material used in making these sleeves.
HOT WATER
Expanding wax puts the squeeze on this Hycar sleeve in the thermostat when water in engine reaches specified temperature. Pressure on Hycar sleeve forces sleeve down along the actuating pin, opening valve plug. When water cools, wax hardens and contracts; spring forces Hycar sleeve back up on pin, closing the thermostat valve.
HYCAR
HOT WATER

Hycar controls heat of automobile engine operation

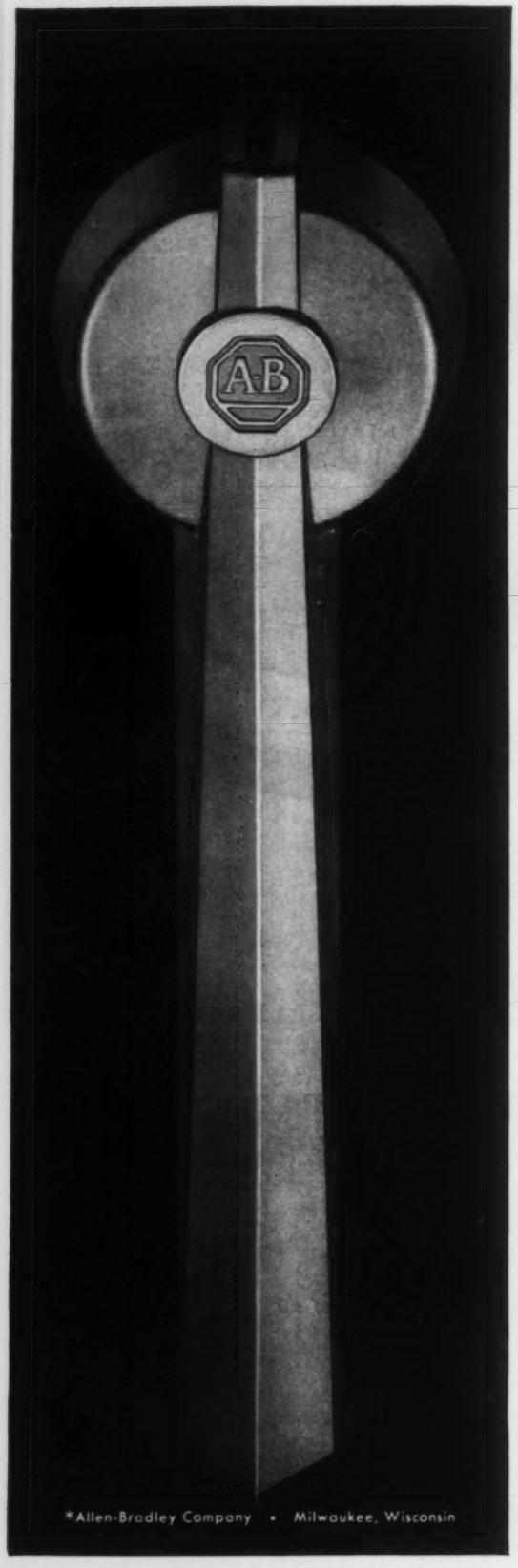
A SLEEVE of Hycar nitrile rubber solves a thermostat operating problem of high pressure cooling systems. Hycar is ideal because it is not affected by antifreeze chemicals or heat. It provides flexibility with high strength and exceptional resistance to volume change and abrasion.

Hycar nitrile rubber makes possible improved existing products and new products, too. Get information on it by writing Dept. KK-3, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar
American Rubber
B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich

GEON polyvinyl materials • HYCAR American rubber and latex
GOOD-RITE chemicals and plasticizers • HARMON colors



Fundamental Characteristics

emphasized in design details with MADISON-KIPP zinc and aluminum die castings

The carry-through designer permits no unworthy detail to mar his fundamental design effect.

Look at the *AB handle here illustrated. The Kipp die casting faithfully protects the product designer's emphasis on superior quality and last word engineering features.

The attentive mechanics at Madison-Kipp invite you to clip this ad as a reminder to contact them for close cooperation on the momentous details of design, when you next have die casting requirements.

kipp

MADISON-KIPP CORPORATION

210 Waubesa Street • Madison 10, Wisconsin

Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering
Originators of Really High Speed Air Tools

Professional Viewpoints

. . . professional prestige . . .

To the Editor:

Your regular articles and editorials on the development of a professional attitude in engineering are outstanding. In my opinion, "Professional Prestige," by Edwin C. Nevis (MACHINE DESIGN, February 20, 1958) was exceptionally so.

This article has led me to submit a few of my own thoughts—which I feel are fundamental—on

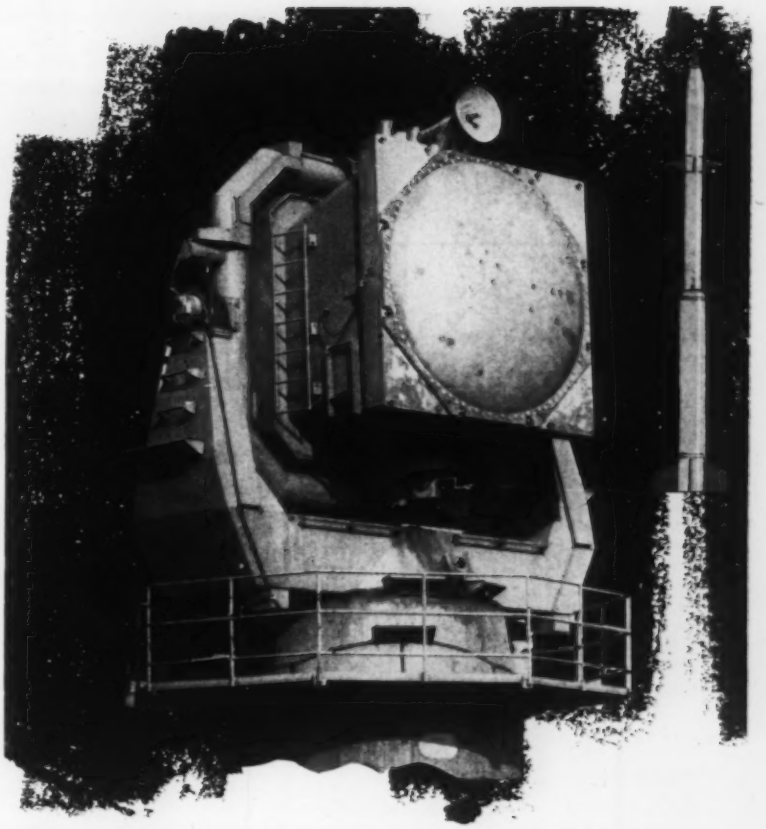
Professional Recognition For Engineers—How and Where

The continuing campaign to obtain increased recognition for engineers is based upon their assumption of a professional status. All are eager to claim the benefits of such a status; many are willing to work for it; yet by some it can never be achieved.

It is often heard that the engineer is of equal importance to society as the doctor and the lawyer; all are college graduates and all are entitled to the same recognition. Does not this simple generality omit many deciding factors?

Each of these groups sells specialized technical knowledge and services, acquired after years of intensive schooling. There are, however, degrees and differences in the preparation required for full standing in the various professions, and the engineers must measure themselves by the common scale.

The established professions require two or three years of preprofessional education on the college level to establish their candidate as a "cultured" man, familiar with the mores and customs of his fellow citizens and thus able to deal effectively with them. This is followed by four or more years of concentrated application to strictly professional subjects. After graduation, the fledgling is further required to serve one, two, or more years as an intern or reader, continuing his studies and securely joining the many



ESCO motors drive 20-ton super radar for terrier missile system!

This extremely accurate, long-range radar provides amazingly advanced defense against supersonic assault from the air. Developed by Sperry Gyroscope Co. for the Navy, it spots and plots the course of distant invaders many miles beyond the horizon. Then in a matter of seconds, it directs the Terrier missile onto the target and relentlessly zeros it in for the kill.

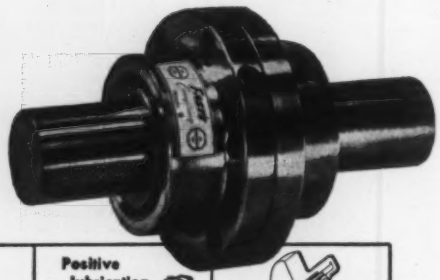
Two stories high and weighing more than 20 tons, almost half this massive system swings in motor-driven gimbals. Sperry chose ESCO for specially designed motors for the elevation, traverse and main drives (shown below), as well as for power-driven doors, and other special applications. In all, over a dozen types of ESCO motors in fractional to 40 hp sizes were designed and built to meet special needs throughout the system.

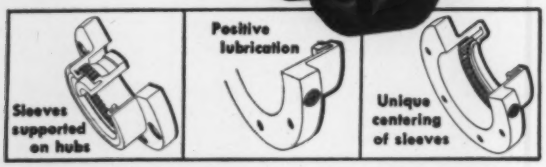
For solving drive problems such as this, ESCO offers invaluable engineering and manufacturing help, with over 40 years experience designing and building nearly every type of special purpose rotating electrical equipment. Write for design and brochure on motors, generators and motor-generators.

ESCO ELECTRIC SPECIALTY CO.
179 South Street, Stamford, Conn.

Circle 563 on Page 19

FAST'S Model B Coupling





reduces downtime and upkeep for light-to-medium drives!

Now you can profit from the durability and economy of famous Fast's couplings in a smaller and lower-cost version—available in 5 sizes for shafts ½" to 3⅛" in diameter.

The Model B coupling gives you the same features that have made Fast's the world's leading coupling for over 35 years. You get the same trouble-free performance, longer service life and lower maintenance costs. You also get prompt delivery because stocks are on hand to meet practically every need. Free engineering service is also available.

Write today for more details to KOPPERS COMPANY, INC., Fast's Coupling Dept., 3506 Scott Street, Baltimore 3, Maryland.

Engineered Products Sold with *Service*

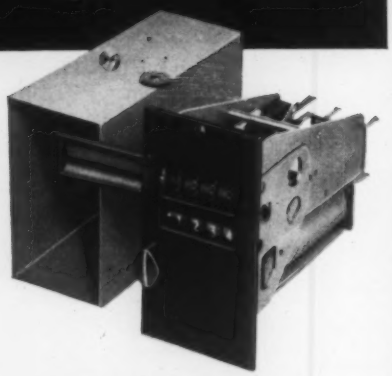
KOPPERS

THE ORIGINAL *FAST'S Couplings*

Circle 564 on Page 19

SODECO'S NEW Predetermining Impulse Counter

Compact



Measures only 3¼"x 1¾"x 3⅜"
Suitable for flush mounting

CONVENIENT PRESET —
Easily accessible setting wheels

FAST RESET —
Manual, or electric for repeat cycling

S.P.D.T. PREDETERMINING SWITCH —
less than 50 ms switching time

LOWER POWER REQUIREMENT —
Counting at 10 i.p.s.—3.8 W;
at 25 i.p.s.—5.1 W.
Reset—7.6 W, all at 110 V. DC.

Write today for your copy of Sodeco Bulletin E-25 which gives full technical information.

LANDIS & GYR, INC.

45 West 45th Street, New York 36, N. Y.

facets of his knowledge. After this service, and after formal examination by his superiors, he is allowed to assume the rank, style, and title of his chosen profession.

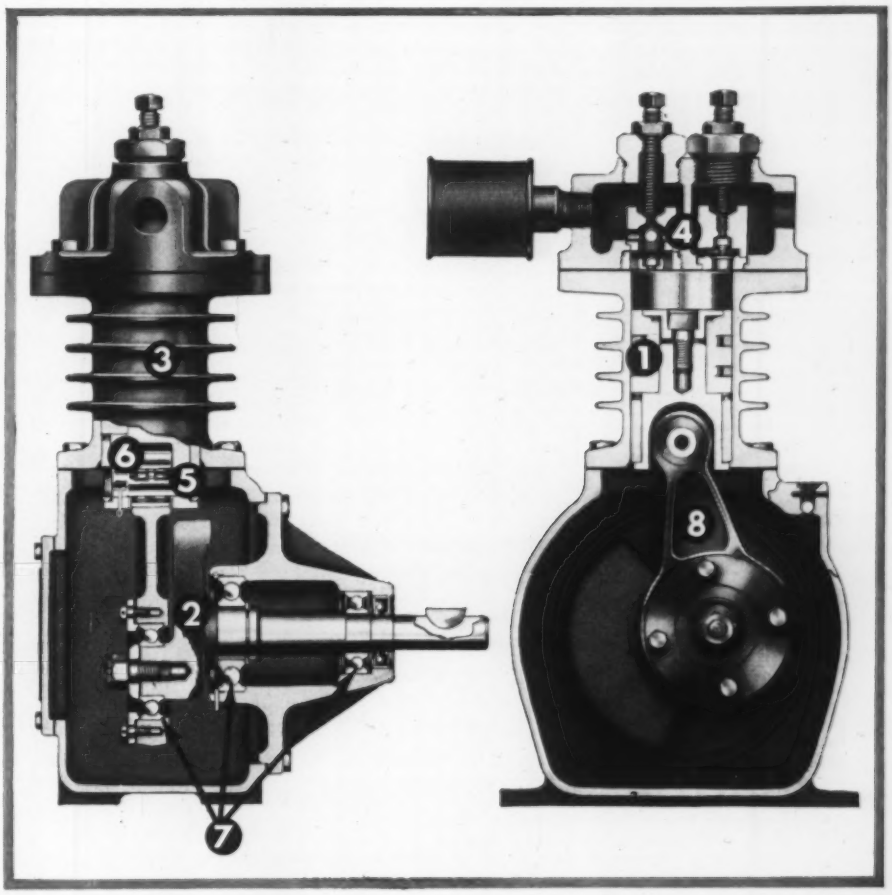
Now, look at the engineer. In the face of unprecedented demand for more and more technical knowledge, few institutions have lengthened the course of instruction beyond the traditional four years. High-school graduation alone is the prerequisite for entering an engineering college. Within the allotted four college years, technical subjects must battle for time with psychology, physical education, religion, government, history, literature, composition, and a host of other subjects. The writer does not deny the value—indeed, the necessity—of these subjects to an educated man, but he does sincerely doubt that they and a good technical education can be crowded into the same four years.

After completing this hectic, hodge-podge four years, the graduate is usually called an engineer and allowed to proceed into the world as though this education were complete. True, under the professional engineering laws, there is a requirement of four years of professional practice before he can be called an Engineer with a capital "E," but this distinction is not yet made by either the general public or the employing public.

Engineering as a profession is advancing. It makes great advances daily, but it has yet to take further measures to set its own house in order. It cannot claim status and recognition for all those who now cluster to its fold. The claim that engineers are equal either culturally or technically to other professional people cannot be substantiated until equivalent professional training is required for entrance to the ranks of engineering.

For example, it is necessary to separate the mechanics from the mechanical engineers. Many people employed under the engineering classification are actually little more than skilled technicians. Necessary as they are to our scientific economy, they cannot be truly considered of professional stature, and their inclusion in the so-called "engineer" group only confuses the public and withholds proper recog-

1. Carbon piston with 2 segmented carbon piston rings.
2. One-piece crankshaft with integral counterweight.
3. Nonlubricated cylinder with large circumferential cooling fins.
4. Individually accessible valve chambers.
5. Carburized, hardened and polished piston pin.
6. Lubrication sealed in heavy-duty needle bearing.
7. Sealed ball bearings eliminate crankcase oil.
8. One-piece connecting rod.



Where can your design use low-cost, oil-free air?

Here are specific instances where oil-free air is desirable for product quality and efficient operation of equipment:

- INSTRUMENTATION
- FOOD PROCESSING
- DENTAL
- MEDICAL
- BREWING
- DISTILLING
- PLASTICS
- CHEMICALS

If *your* equipment calls for oil-free compressed air, design in a small and compact Gardner-Denver CACB compressor. This highly efficient unit uses no oil in the cylinder or crankcase. Pistons and piston rings are made of self-lubricating carbon—no oil or water lubrication is required in the cylinder.

The CACB supplies 4 to 5 cfm of low-cost, oil-free air, with discharge pressures from 40 to 100 psi. Available as a bare compressor or as a complete tank-mounted outfit.

Like all Gardner-Denver products, the CACB is backed by a parts and service network that's strategically located throughout the world. Wherever equipment that you design is put to work, you're sure of factory-trained service on the spot.

For complete information on the CACB, request Bulletin 1-1s.

GARDNER-DENVER Since 1859 — KELLER TOOLS

ENGINEERING FORESIGHT—PROVED ON THE JOB
IN GENERAL INDUSTRY, CONSTRUCTION, PETROLEUM AND MINING

GARDNER-DENVER

Gardner-Denver Company, Quincy, Illinois
In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

Solve Your
HOT PROBLEMS
with
VULCAN
VERSATILITY

in
TUBULAR
HEATERS

Use Vulcan Electric Tubular Heaters when you need considerable heat in confined space: straight or formed in variety of shapes for liquid, gas or metal heating; for casting into iron or aluminum. Threaded fittings are available for liquid immersion heating — water, oil, etc.

You have a wide choice of sizes — 10" to 148" (or longer); diameter — .250", .280", .333", .450"; wattage — 10 to 10,000 (or higher); voltage — standard 120 or 240, special 6 to 480 (or higher); sheaths — copper, steel, high temperature alloys; finned also available.

When your hot problem calls for *unusual* specifications, you get a speedy solution through *Vulcan Versatility* in engineering or production. Standard or special, Vulcan is ready to supply your complete needs in low cost efficient heating units — tubular, immersion, cartridge, strip, finned, band and ring heaters. Send coupon for catalog and prices.

VULCAN
ELECTRIC COMPANY
DANVERS 6, MASS.

Cartridge • Strip • Tubular • Immersion Electric Heaters • Soldering and Branding Irons Solder and Glue Pots

VULCAN ELECTRIC COMPANY
Danvers 6, Mass.

Please send catalog and price information on Vulcan Electric Heaters. I am especially interested in (check):

☐ Tubular ☐ Strip
☐ Immersion ☐ Finned
☐ Cartridge ☐ Other

NAME & TITLE.....
COMPANY.....
STREET & NO.....
CITY & STATE.....

Circle 567 on Page 19

nition from those who are entitled to it.

Such a group now exists, but its semiprofessional position is not clearly defined. It overlaps the Engineers' group. Professional recognition of the latter requires a clear separation between those who hold responsibility for initiating technical action and those who carry it out. The dividing line is not clear, and it will not be established next week, and not without tears and strife. But, as the other professions have established capable and loyal technicians, so will Engineering—eventually.

To receive recognition as professionals, Engineers must continue their efforts to improve the services they render to the public. This improvement must necessarily be based on extensive and better training; continuing devotion to a high standard of professional ethics; and last, but not least, development of a supporting cadre of skilled technical personnel.

—CHARLES E. BALLEISEN
Associate Professor
Mechanical Engineering Dept.
Southern Methodist University

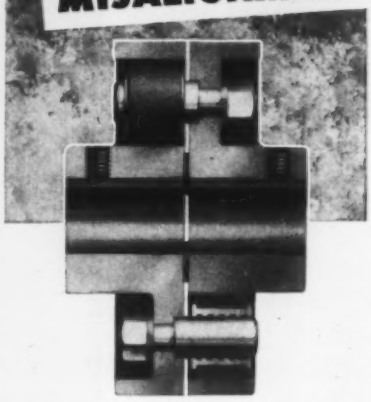
They Say . . .

"As the new areas of scientific discovery draw farther away from what we can see and feel, their applications become more complex and difficult and the men who make these applications must have a deeper and more comprehensive understanding of scientific principles." — MORROUGH P. O'BRIEN, *dean, College of Engineering, University of California, Berkeley, Calif.*

"I would emphasize the need for collaboration between specialist experts in each of the various fields of technology. For example, most problems in mechanical engineering involve considerations of metallurgy, stresses, lubrication, and governing. Very few men have intimate knowledge of each of these subjects, so the ultimate best solution of such questions needs the assistance of appropriate specialists."—SIR GEORGE NELSON, *president, Institute of Electrical Engineers.*

By AJAX

FLEXIBLE
COUPLINGS
CURE YOUR
BREAKDOWNS
DUE TO
MISALIGNMENT

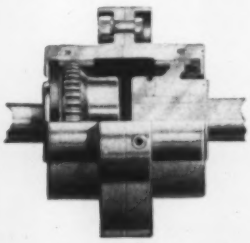


Usually you don't detect misalignment strains until something lets go. That's why it is good preventive practice to specify Ajax Flexible Couplings on new equipment and also install them on your present direct-connected machines. You save wear on bearings, gears, impellers, armatures, and housings.

A shut down machine can shut down a department, and that can cost a thousand times more than an AJAX Flexible Coupling.

Complete lines of AJAX bronze bushed, rubber-cushioned and Dihedral gear couplings... angular and/or offset capacity up to 7 degrees . . . competitive prices.

Write for catalog



AJAX
FLEXIBLE COUPLING CO. INC.
WESTFIELD, N.Y.

Circle 568 on Page 19

STAR-KIMBLE *reports to industry*

One of a series of advertisements describing unusual electro-mechanical problems solved by S-K engineering and equipment. You may have a similar problem—or a completely different one. In either case, bring it to Star-Kimble.

CONSTANT OUTPUT MOTOR ALTERNATOR NEEDS NO EXTERNAL REGULATORS. 600 watt 60 cps output is held at 117 v. ±5% with d-c input varying from 225 to 275 v. Supplies 60 cps for closed circuit TV and other communications and control devices in areas where only 250 v. d-c is normally available. Totally-enclosed, fan-cooled construction for hot, dusty locations; basic design adapted from the thousands of motor alternators which Safety Industries, Inc., has supplied for railway passenger cars throughout the world.

OPERATION FROM −60° TO +120° F -- that was just <u>one</u> of the <u>many</u> environmental conditions that Star-Kimble engineers had to meet in designing a 400 cps, 3 kw output motor-generator for the Armed Services. Imperviousness to snow, rain, sleet, and wind-driven dust was also required. S-K met the specs with a special inductor type alternator having no slip rings, brushes or commutator, thus assuring adequate performance with minimum maintenance.

RUGGED, MOBILE AIR CONDITIONING SYSTEMS manufactured by Safety Industries as an outgrowth of extensive railroad air conditioning experience maintain critical control of temperature and humidity even when ambients vary over extreme ranges. Compact packaged air conditioning systems - 5 to 8 ton capacities - can be specially designed for controlling temperature and humidity in mobile or semi-permanent installations housing complex electronic equipment, such as used by the Armed Services. We invite your inquiry on close-control, self-contained air conditioning systems for your special applications.

Circle 569 on Page 19

STAR-KIMBLE INDUSTRIAL MOTOR DIVISION

SAFETY INDUSTRIES, INC.

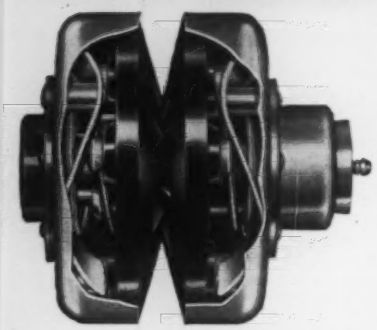
P. O. BOX 904 • TEL. UNiversity 5-3171 • NEW HAVEN 4, CONN.

PINTSCH COMPRESSING CORPORATION
ENTOLETER DIVISION
ELECTRICAL DIVISION

LIGHTING DIVISION
SAFETY RAILWAY SERVICE CORPORATION

AUTOMATIC TIMING & CONTROLS, INC.
THE HOWE SCALE COMPANY
SI HANDLING SYSTEMS

Hi-Lo Load-O-Matic Control Eliminates Pulley Slow Down



Hi-Lo Variable Speed Pulleys positively maintain the desired speed ratio over a wide range of load variation by means of an exclusive cam and cam follower assembly. This means:

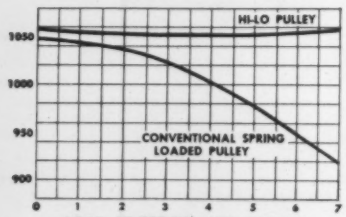
Pulley speed is independent of load and load changes. "Drag" is eliminated and high shock absorbency provided.

Pulleys do not compress belt due to spring pressure. Springs are not driving members. They act only to keep pulley faces in contact with belt.

Pulleys automatically regulate belt tension. Because of the cam assembly, belt is never under more tension than required by the load.

Double cams maintain constant belt alignment.

HI-LO PULLEYS COMPARED TO OTHER VARIABLE SPEED PULLEYS



PLUS THESE OTHER FEATURES:

- Smaller in size than comparable units.
- Quickly and easily installed.
- Replaceable face assemblies drastically cut repair and replacement costs.
- Available in sizes from .5 to 5 hp., ratios to 2.5/1 (single pulley) 6.25/1 (double pulley).

Request details and prices. Ask for Bulletin A-458.

Manufactured By HI-LO MANUFACTURING COMPANY

Nationally Distributed By LOVEJOY FLEXIBLE COUPLING COMPANY
302 N. Lavergne Ave.
Chicago 44, Ill.

Circle 570 on Page 19

THE ENGINEER'S Library

Recent Books

Gas Dynamics. *By Ali Bulent Cambel, Professor and Chairman of Mechanical Engineering, Northwestern University, and Burgess H. Jennings, director of Research Laboratory, American Society of Heating and Airconditioning Engineers; 415 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Company Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$11.00 per copy postpaid.*

This book presents the theory and concepts of compressible fluid flow, wave phenomena, and combustion.

The topics covered include steady, isentropic, diabatic, frictional, and variable-area flow theories, along with some discussion of dimensional analysis and thermochemistry.

The Properties and Testing of Plastics Materials. *By A. E. Lever and J. Rhys; 197 pages, 6 by 9 in., clothbound; published by and available from Chemical Publishing Co. Inc., 212 Fifth Ave., New York 10, N. Y.; $4.75 per copy.*

Contained in this book is technical information on a variety of materials employed in plastics manufacture and use. Some of the general topics included are physical, thermal, optical, electrical, and chemical properties of plastics.

ASME Handbook, Metals Engineering—Processes. *Edited by Roger W. Bolz, Editor of* AUTOMATION. *Published by McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$13.50 per copy postpaid.*

Detailed data on the various processes used in converting metals into finished products are contained in this volume edited by the author of the series on "Production Processes—Their Influence on Design," published in MACHINE DESIGN.

This book is comprised of 45 sections covering heat treatment of

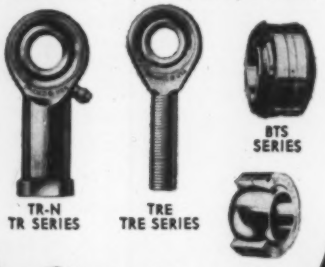
Dependability at every turn!

SPHERCO

SPHERICAL BEARING & ROD ENDS

Cutaway view of TRE Male Rod End.

Spherco Spherical Bearings and Rod Ends are available in a wide range of units and materials, each designed to meet specific requirements. Spherco design features are found in no other bearings or rod ends on the market. Spherco engineers are always at hand to render service and cooperation.



Write for **CATALOG 257**

SPHERCO

A PRODUCT OF
SEALMASTER BEARING DIVISION
STEPHENS-ADAMSON MFG. CO.
18 RIDGEWAY AVE. • AURORA, ILL.

Circle 571 on Page 19

DOES specialized BUSINESS PUBLICATION ADVERTISING HELP SALESMEN?

No one is in a better position to give a hard-boiled, practical answer to this question than the men who spend their working lives on the sales front... the men the ads are supposed to help... the men who sell.

Here is the statement of a salesman who knows what advertising does for him when it appears in the industrial, trade or professional publications that serve the specialized markets to which he sells:

Jack Hegarty
Texas Instruments
Incorporated
sells to industry

says Mr. Hegarty:

"I sell semiconductors and other components to original equipment manufacturers in the electronics field. With the tremendous expansion in the electronic industry today, one of our problems is prompt coverage of the market when a new or improved device is announced. I can contact all my larger accounts within a few days, but it takes considerable time to cover the many smaller accounts.

"That's one of the reasons I think our advertising in business publications is so important. It covers all my prospects, large and small, and gets the story of our products to all three groups that can influence purchases—the engineers, the purchasing agents and top management. In some accounts 50 or 60 engineers will attend a meeting. However, there are still many decision-making personnel who can't attend because of other demands on their time. But I know that they will get our story from our advertising.

"On cold calls, many times my selling effort is greatly assisted by the 'pre-selling' of our advertising and it seems to me that advertising often gets me an entree at a higher level than I can usually get on cold calls.

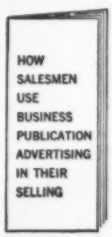
"It helps in other ways, too. For instance, we get inquiries for applications and devices that haven't been developed by our company. Prospects read the advertising, get clues, then contact us. In one case we ran an ad that basically showed a specification sheet on a new component. On one inquiry I followed up, the engineer had the magazine open on his desk right at our ad. He asked me, 'Can you meet this spec?' It was different—but, by some specialized design work, something we could do. I secured a first release order for over $70,000 just from this one inquiry.

"While my division of our corporation had first established its name in the industry on the basis of its work in semiconductors, we also manufacture many other components. They are in competition with units of companies longer established than we are. Here our advertising helps establish our name as a progressive company with a dependable reputation, good to deal with."

Ask your own salesmen what your company's business publication advertising does for them. If their answers are generally favorable, you can be sure that it is really helping them sell. If too many answers are negative, it could well pay you to review your advertising objectives — and to make sure the publications that carry your advertising are read by the men who must be sold.

How salesmen use their companies' advertising to get more business

Here's a useful package of ideas for the sales manager, advertising manager or agency man who would like to get more horsepower out of his advertising. Send for a free copy of the pocket size booklet which reports the successful methods employed by eleven salesmen who tell how they get more value out of their companies' business publication advertising.



You can be sure that more of your salesmen will use your advertising after they read how others get business through these simple methods.

The coupon is for your convenience in sending for your free copy.

NATIONAL BUSINESS PUBLICATIONS, INC.

NBP

...each of which serves a specialized market in a specific industry, trade or profession.

NATIONAL BUSINESS PUBLICATIONS, INC.
Department 12D
1413 K Street, N. W.
Washington 5, D. C. STerling 3-7533

Please send me a free copy of the NBP booklet "How Salesmen Use Business Publication Advertising in Their Selling."

Name _____

Title _____

Company _____

Street Address _____

City _____ Zone _____ State _____

HOW TO GET *MORE* FOR YOUR CASTING DOLLAR

Accurate analysis of your casting costs should include a thorough knowledge of the scope of your suppliers' operations. Monarch's new brochure gives you an informative guide to our modern manufacturing methods.

- ✔ Growth of casting usage
- ✔ Plant facilities and services
- ✔ Aluminum permanent mold castings
- ✔ Aluminum and certified zinc diecastings
- ✔ Automated permanent mold trimming
- ✔ Mechanized diecast trimming
- ✔ Secondary machining operations
- ✔ Custom finishing
- ✔ Exclusive Monarch finishes
- ✔ Casting engineering analysis
- ✔ Production control

Send for your copy today.

MANUFACTURING in MOLTEN ACHIEVEMENTS ALUMINUM

MONARCH ALUMINUM MFG. COMPANY

9205 Detroit Avenue Cleveland 2, Ohio

Circle 573 on Page 19

steel, casting, hot and cold working, powder metallurgy, welding, machining, and electro-forming. Woven throughout this book is considerable general information on metal properties and characteristics of value to the design engineer.

Engineering Manpower: How to Improve Its Productivity. *By George A. von Peterffy, et al; 162 pages, 8½ by 11 in., paperbound; published by and available from Engineering Management Reports, P. O. Box 161, Cambridge 38, Mass.; $18.50 per copy.*

This book, a research report by nine students at the Graduate School of Business Administration at Harvard University, describes the philosophy, policies, and practices of American industrial concerns toward their technical personnel.

The recent 12-part series in MACHINE DESIGN, "Challenge for 1958—Organizing for Productivity," has been adapted from this book.

Techniques of Pressworking Sheet Metal. *By Donald F. Eary and Edward A. Reed; 472 pages, 6 by 9 in., clothbound; published by Prentice-Hall Inc., 70 Fifth Ave., New York 11, N. Y.; available from* MACHINE DESIGN, *$12.00 per copy postpaid.*

Design reference information is contained in this book which covers press types, sheet-metal operations, mechanical handling devices, and tool-steel selection.

Although this book is of particular interest to those concerned with the design of dies, there is considerable background information presented which would be useful to press component and mechanical handling equipment designers.

New Standards

American Standard Mounting Dimensions of Lubricating and Coolant Pumps for Machine Tools. *11 pages, 8½ by 11 in.; published by and available from The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $1.00 per copy.*

This standard establishes mounting dimensions for foot, bracket, and motor-mounted lubricating and

New *** Revolutionary

GRATON AND KNIGHT

NYCOR

FLAT BELTING

Whatever your drive . . . you'll transmit maximum power longer with G&K Nycor belting. Your own tests will prove that Nycor belts deliver more horsepower over longer periods of time than ordinary transmission belting.

The stretchless feature of this belt eliminates take-ups and costly down time. In many instances conventional belting is replaced with Nycor at one half the width formerly used, reflecting tremendous savings on initial cost. LET US DEMONSTRATE THE DIFFERENCE!

Send For Brochure on Nycor Belting

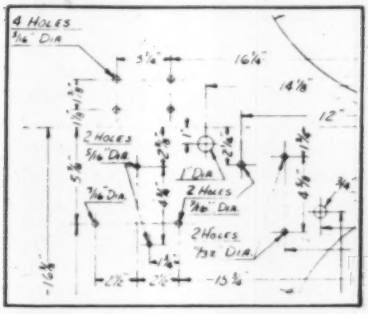
GRATON & KNIGHT Company INC.

WORCESTER 4, MASSACHUSETTS

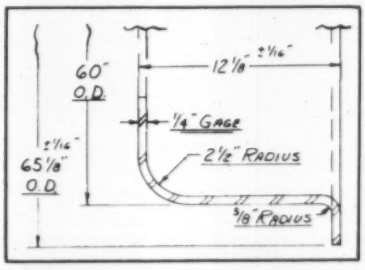
Circle 574 on Page 19

How accuracy is assured in every stamped component part...

Mechanical means in the stamping operation produce identical parts by tens, hundreds, or thousands. For this reason, once the die for any particular component is accurately produced, every part it helps to stamp is completely accurate with near-perfect tolerances—and without involving any appreciable dependence on operator judgement or skill.



Selection of materials from which stampings are produced involves a product that possesses uniformity. Freedom from raw material variables eliminates the necessity for additional processing of materials prior to producing stampings. Accuracy of stampings is predictable because they are produced to designed size and shape subject to predetermined tolerances. The only limits to the accuracy which can be stamped into a component part are the tolerances specified by the customer and the technical skill and experience of the supplier.

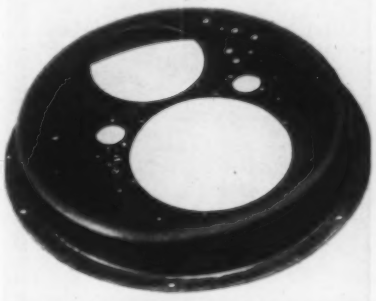


The greater accuracy afforded by the stamping method obviously leads to many important savings in the complete production operation—invariably means lower product cost. Because accuracy in stampings is identical—almost automatic—it involves no time lag, requires less man and machine hours to gain. At the same time, greater accuracy naturally means fewer rejects and less waste of raw material.

Gang-piercing Expels Errors

63 holes gang-pierced to near-perfect tolerances in 60" diameter stamped boiler doors

Exact dimensional sizing and accurate gang-piercing of all holes—eliminating chance of accumulative error—is a primary requirement in the dished boiler doors being produced for the Cleaver-Brooks Company. Equally important is close adherence to a tolerance of plus or minus 1/16" on diameter, and flat across the flange within 1/16".



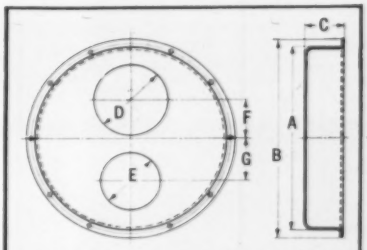
The close tolerances of the 63 holes in the dished boiler door assure the accurate mounting of standard controls, burners and blowers.

Identical Parts—Gang-piercing of the required holes in the Cleaver-Brooks boiler doors—involving a one-hit operation—insured identical dimensional and location accuracy of all holes at lower cost. Size and flatness of the one-piece stamped doors had to be maintained to tight tolerances even after the gang-piercing operation in order to guarantee perfect fit and draft-free closing seal.

The one-piece dished boiler doors are important components in a new line of Cleaver-Brooks boilers which feature forced draft and easy boiler access.

In terms of money—When other fabricating methods proved unsatisfactory and too expensive, Cleaver-Brooks turned to COMMERCIAL. Dies for the stampings were designed and produced by COMMERCIAL and the boiler doors are now turned out on a regular production basis on a 2000-ton mechanical press with an 8 x 16-ft. bed and a 30-in. stroke.

The close dimensional tolerances of the multiple holes in the boiler doors eliminate the need for further reaming. The exact spacing of all holes, which is completely free of *any* accumulative error, makes it possible to mount boiler accessories directly to the boiler doors without any assembly time lag. Also eliminated, thanks to gang-piercing, is the need for any flat surface facing before accessories can be mounted.



A	B	C	D	E	F	G
36	40	6¼	16¾	12⅝	7	8⅛
48	53	8½	20	16½	11¼	10¾
60	65⅛	12⅛	23⅜	18⅝	12⅝	14

Further savings—Other costly and time consuming operations formerly required—flame cutting, rolling rings, machining edges, welding, weld inspection, cutting holes, etc., not to mention the use of many expensive fixtures—have all been eliminated by the COMMERCIAL produced heavy stampings. Best of all, distortion which was formerly sometimes inevitable has now been replaced by near-perfect accuracy in every boiler door stamped for the new outstanding line of Cleaver-Brooks boilers.

Whatever your particular component part design problem may be, we may be able to suggest and help you work out a practical and economical solution based on our more than 30 years experience in forming metals. Send details of your problem to Commercial Shearing & Stamping Company, Dept. S-24, Youngstown, Ohio.

COMMERCIAL shearing & stamping

Circle 575 on Page 19

JAEGER DEPENDS ON

ROPER PUMPS

...so can you

TWO STAGE ROTARY COMPRESSOR COOLED BY ITS OWN LUBRICATING OIL

Typical of Roper adaptability to heavy duty equipment is this installation on the Jaeger Roto Air-Plus, 2-stage rotary compressor. The pump sprays cooled, filtered oil onto the rotor and bearings in high and low compressor cylinders in order to lubricate all surfaces and seal against air leakage. The efficiency of the cooling system insures cool operation in ambient temperatures exceeding 100°. Arrangement of the system is such that oil-free air reaches the air service valve.

The Jaeger compressor has established service records of maintaining 100 lbs. constant pressure for 160 hours, without let-up — a tribute to the unit's dependability, and the Roper that helps cool it.

For OEM... Specify ROPER

In this instance, the Series K pump is suited to the Jaeger application. This series is available in sizes ¾ to 50 GPM, pressures to 150 PSI. It is a rotary gear unit, with sizes 10 through 50 featuring the patented venturi suction and discharge principle for smooth, quiet operation.

ROPER HYDRAULICS, INC.

Send for Bulletins Today

246 BLACKHAWK PARK AVE., ROCKFORD, ILL.

coolant pumps incorporated on machine tools.

Military Standards for Printed Circuits. *20 pages, 5½ by 8½ in., paperbound; published by and available from Cleveland Metal Specialties Co., 1783 East 21st St., Cleveland 14, Ohio; $0.75 per copy.*

This book contains specifications on printed-circuit boards and information on their design and construction.

American Standard Machine Pins. *14 pages, 8½ by 11 in., paperbound; published by and available from The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $1.50 per copy.*

One of a series of standards for small tool and machine tool elements, this pamphlet contains standards on dowel, taper, clevis, grooved, and cotter pins.

Association Publications

Thermal Properties of Thirteen Metals. *By C. F. Lucks and H. W. Deem; 30 pages, 6 by 9 in., paperbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $1.25 per copy.*

Thermal - conductivity, linear - thermal - expansion, specific - heat, density, and thermal-diffusivity values are compiled in this book for 13 metals including aluminum, copper, magnesium, and steel.

Symposium on Large Fatigue Testing Machines and Their Results. *162 pages, 6 by 9 in., hard cover; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $4.25 per copy.*

The papers presented in this book deal with the experimental difficulties, interpretation of data, and new techniques used in fatigue testing large specimens.

Maintainability of Electronic Systems. *published by and available from Engineering Publishers, GPO Box 1151, New York 1, N. Y.; $5.00 per copy.*

Proceedings of the Electronic In-

dustries Association Symposium make up the contents of this book. The subject matter includes the concepts and requirements for maintainability of electronic equipment, as well as practical methods by which maintainability can be designed into the equipment.

Instrumentation and Control in the Process Industries. *145 pages, 5½ by 8½ in., paperbound; published by and available from Armour Research Foundation of Illinois Institute of Technology, Chicago 16, Ill.; $4.00 per copy.*

This book contains twelve papers presented at the Second Conference on Instrumentation and Control in the Process Industries. Topics included are standards, applications, and developments of process instruments and controls.

Manufacturers' Publications

Pressure-Temperature Bulletin, FB-77. *48 pages, 8½ by 11 in., paperbound; published by and available from The Babcock and Wilcox Co., 3839 West Burnham St., Milwaukee 46, Wis.*

This bulletin correlates and summarizes the specifications of the ASA Pressure Piping and ASME Boiler and Pressure Vessel Codes which pertain to pressure piping. Some of the information contained includes basic Code formulas, allowable stress values, and minimum pressure-stress ratios.

Government Publications

OTS Research Reports. *Each publication is 8 by 10½ in., paperbound, and side-stapled; copies are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.*

The following reports are available:

Proceedings of the 1955 Sagamore Research Conference — Strength Limitations of Metals, Volume 1, PB 131280. 204 pages, $5.50 per copy.

Proceedings of the 1955 Sagamore Research Conference — Strength Limitations of Metals, Volume 2, PB 131281. 200 pages, $5.00 per copy.

WHAT'S THE CATCH?

The catch or latching arrangement on all these Sigma relays is a permanent magnet. While this fact is not fraught with serious or far-reaching consequences, magnetic latching does have advantages worth considering. Since there are no triggers, catches or springs to wear out, magnetic latching relays do not fear early commitment to an eleemosynary institution. They do not continuously nibble a little stand-by power, adding their own little body warmth to the already stuffy environment; nor do power interruptions make them change position. What the armatures of these Sigma relays *do* do is stay where the last coil signal sent them, moving to the other fixed position only when a resetting signal comes along.

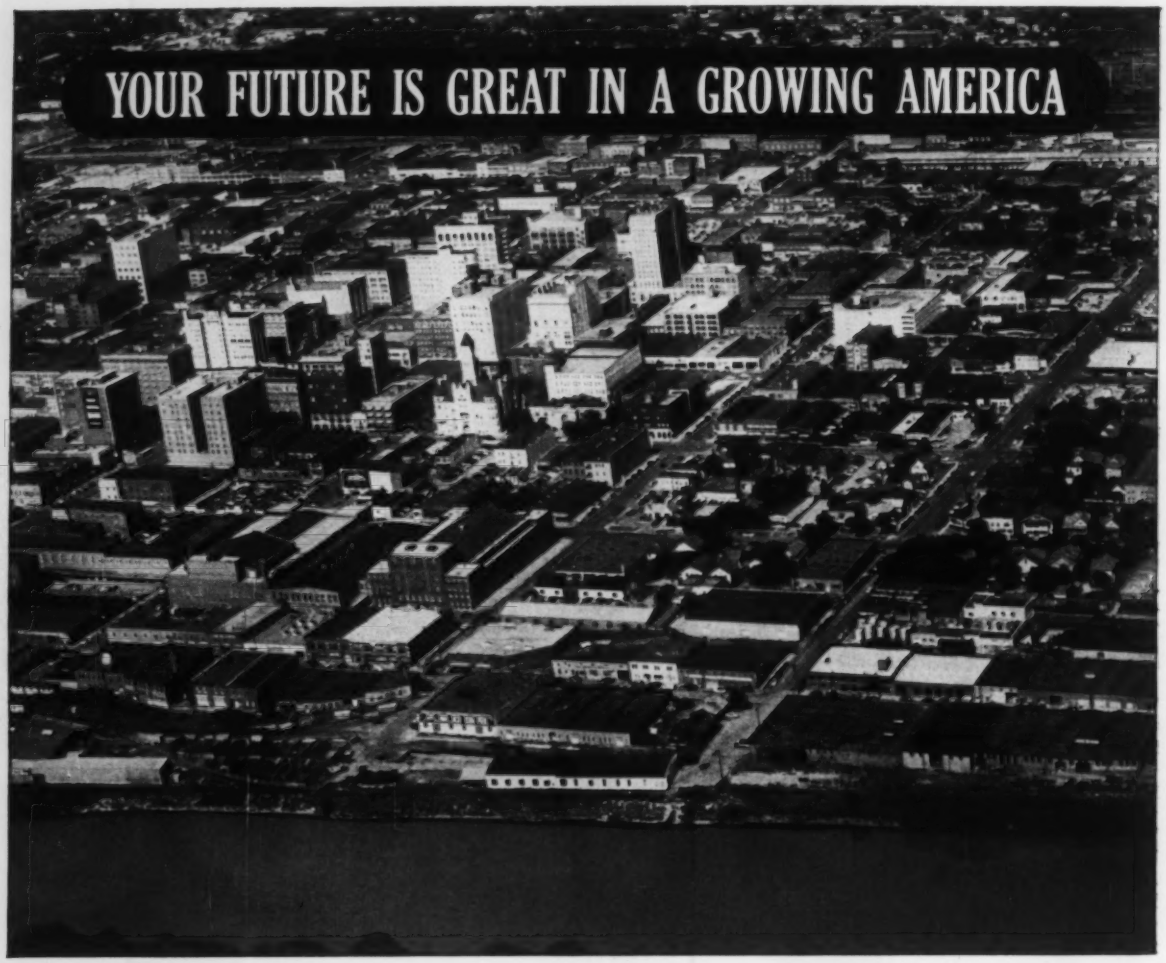
An up-to-date inventory shows that there are now five Sigma magnetic latching relays available, with the following distinguishing traits. **SERIES 6** will switch 2 or 5 ampere loads on inputs from 22 to 450 mw., with contacts up to 4PDT; useful in memory circuits, fast enough for follow-up systems, reliable latching contactor. **SERIES 61** is a modification of the "6", with DPDT contacts capable of switching 20 ampere loads on 225 or 450 mw. signals; small, considering its ratings. **SERIES 32** is the newest and smallest of the group; DPDT, measures 0.800" x 0.400" x 0.900" high, max., has pins spaced equally on 0.200" centers; price is low. **SERIES 72** is the most sensitive (0.3 — 2.0 mw), and is designed for bounce-free, high speed switching. Sensitivity is adjustable, contacts replaceable. **SERIES 73** is a small hermetically sealed SPDT type for use in miniature devices and guided missiles. Dimensions ¾" dia. x 1 11/16" high. Contacts rated 1.5 ampere, sensitivity 6 mw. and 12 mw.

If any of these magnetic latching relays (Sigma Form "Z") offer the characteristics you're looking for, write for more data. If they don't, write anyway and tell us what you expect. Maybe one of us could be talked into making a small modification, so that a Sigma relay *will* work.

SIGMA

SIGMA INSTRUMENTS, INC.,
89 Pearl Street, So. Braintree 85, Mass.

Circle 577 on Page 19



THE CITY THAT DIDN'T EXIST A MONTH AGO

Every 30 days the U. S. adds as many new Americans as live in Norfolk, Va.—creating brand-new wants and needs which must be satisfied.

What does this mean to you? It means greater opportunities than ever before—in all fields. Home construction is expected to double by 1975. Power companies plan to increase output 250% in the next 20 years to provide the power for scores of new labor-saving devices. Clothing suppliers predict a one-third increase in 7 years.

With 11,000 new citizen-consumers born every day, there's a new wave of opportunity coming.

7 BIG REASONS FOR CONFIDENCE IN AMERICA'S FUTURE

1. **More people** . . . Four million babies yearly. U. S. population has *doubled* in last 50 years! And our prosperity curve has always followed our population curve.
2. **More jobs** . . . Though employment in some areas has fallen off, there are *15 million* more jobs than in 1939—and there will be *22 million more* in 1975 than today.
3. **More income** . . . Family income after taxes is at an all-time high of $5300—is expected to pass $7000 by 1975.
4. **More production** . . . U. S. production *doubles* every 20 years. We will require millions more people to make, sell and distribute our products.
5. **More savings** . . . Individual savings are at highest level ever—*$340 billion*—a record amount available for spending.
6. **More research** . . . *$10 billion* spent each year will pay off in more jobs, better living, whole new industries.
7. **More needs** . . . In the next few years we will need *$500 billion* worth of schools, highways, homes, durable equipment. Meeting these needs will create new opportunities for everyone.

Add them up and you have the makings of another big upswing. Wise planners, builders and buyers will act *now* to get ready for it.

FREE! Send for this new 24-page illustrated booklet, "Your Great Future in a Growing America." Every American should know these facts. Drop a card today to: ADVERTISING COUNCIL, Box 10, Midtown Station, New York 18, N. Y.

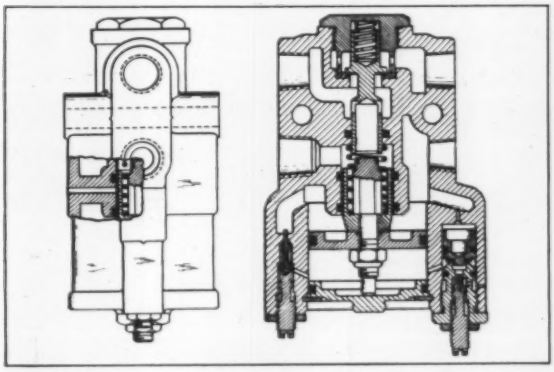
(This space contributed as a public service by this magazine.)

NOTEWORTHY

Patents

Time-Delay Valve

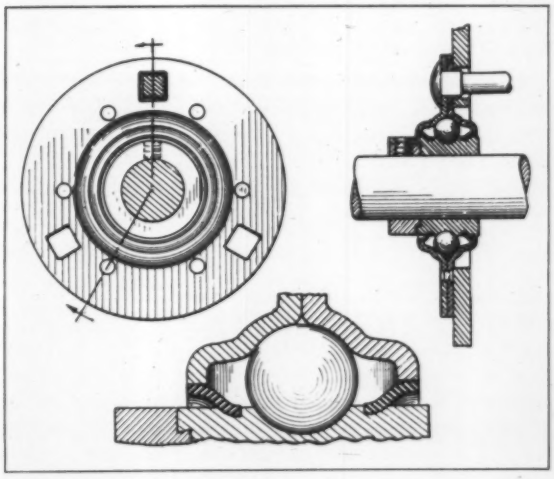
A momentary air impulse, fed to the pilot section of a time-delay valve, initiates a cycle of operation with duration ranging from a fraction of a second to



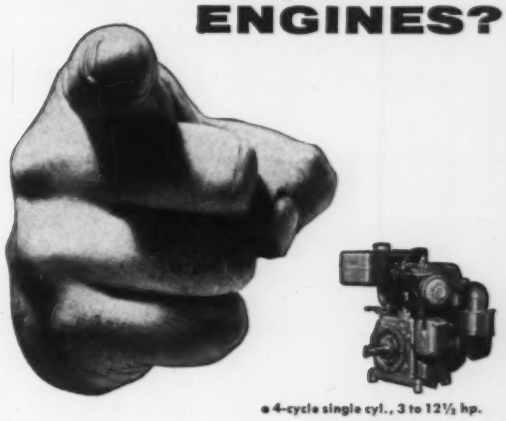
several minutes. Typical use of the valve is for metering a quantity of air, oil, or water, or for timing the stroke of an actuating cylinder. Time lag between the initiating impulse and the start of the controlled function, as well as the duration of the controlled function, can be varied by adjustable needle valves. *Patent 2,815,042 assigned to Scovill Mfg. Co., Waterbury, Conn., by Charles Passaggio.*

Sealed Bearing

Elastomer seal rings are replaceable in a flange-mounted ball bearing. Snapped into place after the bearing is assembled and lubricated, the seal rings can be pushed aside to allow relubrication during the service

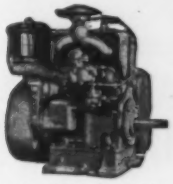


WHO specifies WISCONSIN heavy-duty Air-Cooled ENGINES?

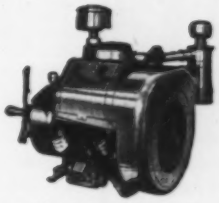


• 4-cycle single cyl., 3 to 12½ hp.

A Good Question... and here's the answer



• 2-cylinder, 10 to 18 hp.



• V-type 4-cyl., 15 to 56 hp.

IT'S the seasoned "professionals" . . . qualified men like yourself, who *know engines* and the operating demands they must meet in rugged field service, who specify "Wisconsin Power" . . .

Men like *you*, who have had the opportunity to compare and weigh performance characteristics of engines on your own equipment, under your conditions;

Men like *you*, who appreciate the advantages of Wisconsin heavy-duty design and construction in all details . . . in terms of operating dependability; low-cost maintenance and long engine life;

Men like *you*, who know the value of Wisconsin High Torque engineering and performance . . . to give you the load-holding *Lugging Power* that hangs on through the shock-load pinches without stalling;

Men like *you*, who have learned from experience that there is no substitute for Wisconsin trouble-free AIR-COOLING . . . efficient at all temperatures from sub-zero to 140° F.

Full scale *specialization* in the manufacture of heavy-duty air-cooled engines and a full line of 4-cycle single cylinder, 2- and V-type 4-cylinder models from 3 to 56 hp. (all models can be equipped with convenient, quick-action ELECTRIC STARTING) are additional reasons why *power professionals*, like you, specify "WISCONSIN." Write for engine bulletin S-223 for a briefing on the full line.

WISCONSIN MOTOR CORPORATION

AS-6178½A

Mac-it Socket Head Cap Screw being tightened

correct tightening = peak holding power

When you buy screws, you're buying *holding power*. But you realize the full value of a screw's holding power only when the screw is properly tightened with the correct torque.

Correct tightening of Mac-it Socket Head Cap Screws is readily accomplished with the aid of a new Mac-it **Design & Assembly Guide** which presents complete tightening torque recommendations. This assures more accurate design and assembly practice. Full use of the inherently greater strength of Mac-it Screws can mean vital cost savings.

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When you want powerful holding, specify Mac-it—the screws that hold where others fail!

Mac-it Screw Division
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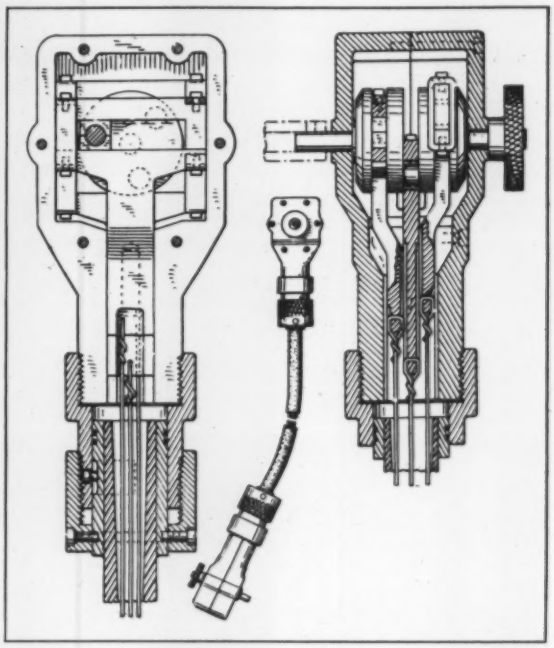
1392 West 3rd Street, Cleveland 13, Ohio

Buy Mac-it Screws from your distributor:
Socket Head Cap Screws • Flat Head Socket Cap Screws • Button Head Socket Cap Screws • Socket Head Shoulder Screws • Hollow Set Screws • Hollow Lock Screws • Hex Socket Keys • Square Head Set Screws • Hex Head Cap Screws • Tool Post Screws • Square Head Collar Cap Screws • Specials

life of the bearing. *Patent 2,823,967 assigned to Parkersburg-Aetna Corp., Chicago, Ill., by Richard Harrington.*

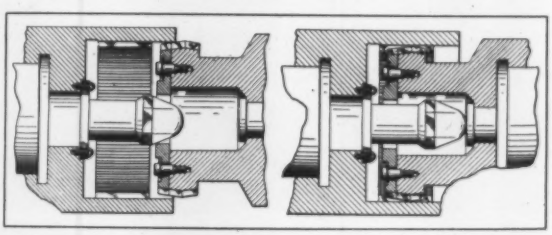
Flexible Drive Mechanism

Three reciprocating wires, connected at their ends to multiple-throw cranks, transmit rotational motion between heads of a flexible drive mechanism. In operation, the crank shaft in the driving head is coupled to a source of power; rotation of the driving-head shaft is converted to reciprocating wire motion by three cross heads (Scotch yokes). An identical mechanism in the driven head converts wire translation to shaft rotation. Designed to transfer power or control motion with minimum backlash in either direction, the unit can be "inched" by turning the knurled knob on either head. *Patent 2,822,697 assigned to Lee Engineering Co., Milwaukee, Wis., by Royal Lee.*



Gear-Type Shaft Coupling

Coupling halves automatically assume concentric positions and teeth mesh without clashing when a gear-type shaft coupling is telescoped into engagement.

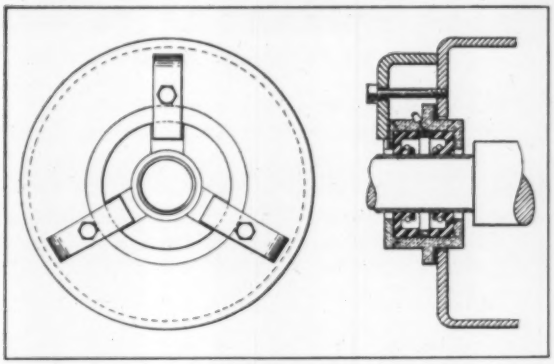


Assembly is accomplished by translating one coupling member axially so as to mate a hexagonal-section on an indexing post with a hexagonal aperture. Unit

transfers rotational motion between angularly misaligned shafts without backlash or binding. *Patent 2,823,527 assigned to Ajax Flexible Co., Westfield, N. Y., by Charles W. Belden and Harley C. Northrop.*

Seal and Housing Assembly

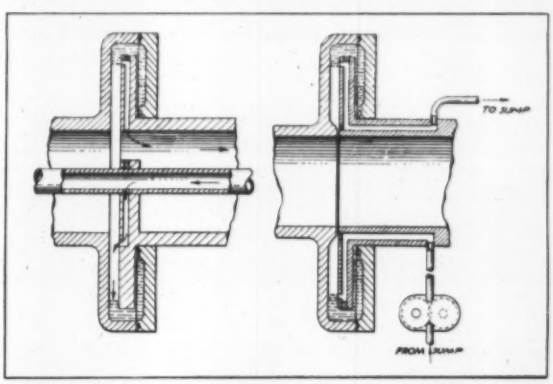
Designed to accommodate eccentric shaft rotation in low-precision installations such as laundry and dry-cleaning machinery, a seal and housing assembly elim-



inates need for accurate centering of seal and shaft axes. Principal sealing elements are a pair of garter-spring loaded elastomer rings. Bronze shaft sleeve permits use of the assembly in corrosive fluids. Seal housing is held to the machine frame by spaced L-shaped clamps. *Patent 2,818,283 assigned to Cummings-Landau Laundry Machinery Co. Inc., Brooklyn, N. Y., by Martin Hutterer.*

Fluid-Sealed Rotating Joint

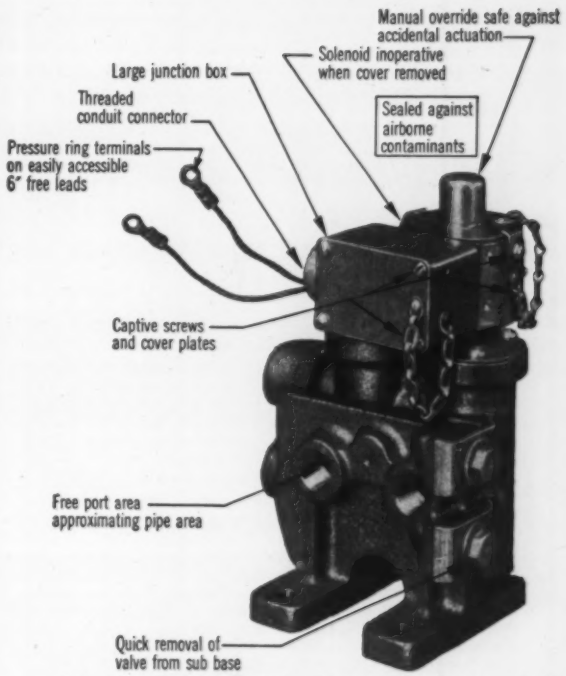
Gases or liquids can be transferred between axially abutting shafts (one fixed, one rotating) when the joint is made liquid tight by a fluid-sealed rotating joint.



Left-hand sketch shows unit configuration wherein sealing and sealed fluids are mixed and carried away in a common passage. Modified unit (right) carries sealing fluid away from the joint in a separate passage. Inlet and outlet ports in the stationary disc maintain proper fluid level in the sealing chamber when sealing fluid is continuously circulated for cooling purposes. *Patent 2,823,052 assigned to General Motors Corp., Detroit, Mich., by John S. Collman.*

NO SOLENOID TROUBLES

with Crescent® Valves


Manual override safe against accidental actuation
Solenoid inoperative when cover removed
Large junction box
Threaded conduit connector
Sealed against airborne contaminants
Pressure ring terminals on easily accessible 6" free leads
Captive screws and cover plates
Free port area approximating pipe area
Quick removal of valve from sub base

®Product of Crescent Valve Company for the control of air, water and light oil to 150 P.S.I.

Pointed out on the photo above are the JIC features which are a must for many equipment manufacturers to gain acceptance of their machines in a growing number of production conscious plants. However, they offer obvious advantages even where they are not specifically demanded. Furthermore the JIC type Crescent solenoid is completely interchangeable with standard solenoids for the convenience of those manufacturers who want the JIC features available only for required application.

COMPETITIVE
With all its superior operating features the Crescent valve is probably the most competitively priced line on the market, particularly in the light of liberal trade and quantity discounts.

COMPACTNESS
Space, labor and materials savings have been pointed out to us by many equipment manufacturers as benefits from Crescent's compact design.

INTERCHANGEABILITY
Crescent valves can be converted to any practical current or voltage AC or DC by a simple coil change.

NO COIL BURNOUT
Short stroke, pilot operation and a generous power margin prevent overheating, overloading and the resultant coil burnout.

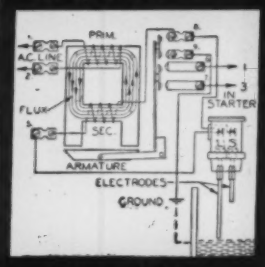
Write for Catalog 6-C

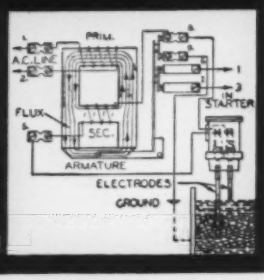
CONTROL VALVE DIVISION **barksdale valves**

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

Circle 581 on Page 19

LIQUID LEVEL CONTROL
with the
B/W RELAY





Type LH Relay
for
Pump Down Control

POSITIVE AND DEPENDABLE

The B/W system of liquid level control consists of a transformer type induction relay and a holder for one or two electrodes, depending on the desired operation and the type of relay used. The relay incorporates a primary or line voltage coil connected to a permanent source of alternating current, and a secondary or electrode circuit coil connected to the electrodes immersed in the liquid being controlled. Energizing the primary coil causes an induced voltage in the secondary coil; thus the secondary coil is never connected to the power line.

LIQUID IS ELECTRICAL CONDUCTOR

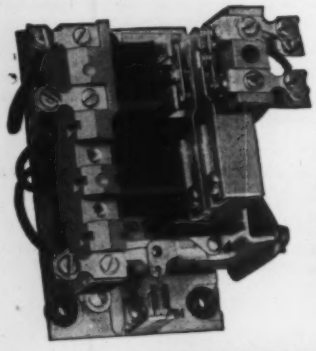
The liquid itself is the electrical conductor that completes the secondary circuit. When this secondary circuit is completed, by the liquid contacting both electrodes, the magnetic attraction set up in the legs of the relay core causes the armature to close, and open or close the load contacts. A built-in holding circuit maintains this contact until a predetermined fall in liquid level breaks the circuit. By adjusting the electrode settings, the range of operation can be controlled.

FOR PUMP UP and PUMP DOWN APPLICATIONS, SIGNALS and ALARMS

B/W relays are designed for either pump up or pump down operation. In addition, by using a single electrode they are well suited for signal and alarm applications.

NO MOVING PARTS

The complete absence of moving parts in the liquid insures long and trouble-free performance. Because of the very low current in the secondary circuit these relays are ideal for many switching jobs outside of the liquid level field. Consult our engineering department on any special control applications.



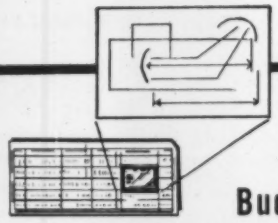
CATALOG on request

• It covers the complete line of B/W Induction Relays, Enclosures, Contactors and Starters, Multiple Pump Controls, Electrode Holders, Starter and Relay Combinations, Special Controls and Panels.

B/W CONTROLLER CORPORATION
2180 E. Maple Road, Birmingham, Mich.

FIRST IN THE FLOATLESS CONTROL FIELD

Circle 582 on Page 19



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Many are the reasons why companies use Filmsort aperture cards for engineering drawings.

One company saves enough on its fire insurance premium to pay for the system; another gets its savings from vault space. A third says it is the only way to have real security.

Maybe the fourth has the best reason of all—it finds its engineers have more time to engineer. You will agree these are four good reasons for reading our booklet, "The Filmsort Aperture Card for Your Engineering Drawings and Allied Records".

The Filmsort Company
Pearl River, New York
A DIVISION OF MIEHLE-GOSS-DEXTER, INC.

Circle 583 on Page 19

NOW YOU CAN TAKE ANOTHER LOOK AT

BEVEL GEARS

Designers can now re-consider the use of bevel gears—due to the latest Gleason coniflex system of bevel gear proportions which we employ—to minimize gear mounting problems and for less trouble after assembly. Costs are less by this method, better finishes and smoother gear operations are a result, and because bevel gears are so efficient, they can now be used more extensively than ever before.

We can make bevel gears up to 3" in diameter with up to 16 diametral pitch for such products as instruments, power tools, differentials, appliances, and fishing reels. Process bevel gears are precision engineered, deliveries are prompt.

Send blue prints or specs for prompt estimates to the specialists in the Fine Pitch Field.

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Circle 584 on Page 19

SAVE Time, Expense and Effort with ANCHOR FLANCO®

4-Bolt, Split-Flange, "O" Ring CLAMP

—with the TILT-PROOF and BLOW-OFF PROOF DESIGN

It provides an easily made, leak-proof "O" Ring Head Connection, with no threads to wear out or tapered seats to groove — no wedging of pump or valve bodies by tapered pipe threads. Gaskets and sealing compounds are eliminated. The higher the pressure, the tighter the "O" Ring seals.

Anchor Flanco Split-Flange Couplings are used to connect hose to valve or pump bodies, hose to hose and hose to pipe. Designed for high or low pressure, available in ½" to 3" I.D. Hose.

Available 4 Ways

- Pressed-On Couplings — utilizing Anchor's time-proved swaging methods.
- Clamp-Type Couplings — ideal for emergency repair.
- Weld-Type Couplings — for connecting pipe or tubing.
- Stem Angles — 0° to 90°, with Flanco Swivel Split-Flange's 360° swiveling, they provide universal coupling.

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Circle 585 on Page 19

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REGARDLESS OF YOUR NEEDS WE CAN SUPPLY THEM

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Delivery to meet your requirements.

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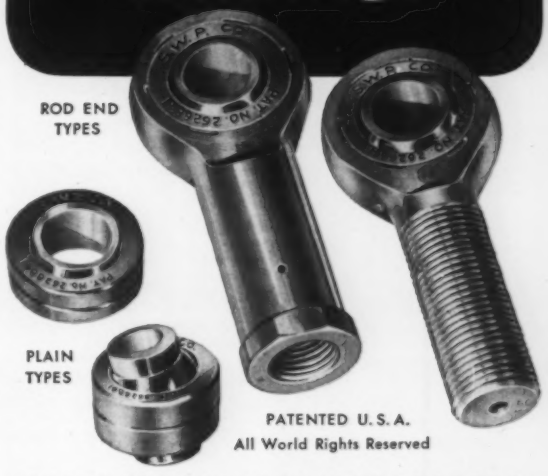
"MONOBALL" Self-Aligning Bearings

ROD END TYPES

PLAIN TYPES



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Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for revised Engineering Manual describing complete line. Address Dept. MD-58.

SOUTHWEST PRODUCTS CO.
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FOR OPERATING PRESS

PROBLEM: The Compo Shoe Machinery Corporation of Waltham, Massachusetts, wanted a valve that would assure reliable cam operation in conjunction with a foot-operated valve (not shown) of their dual-head press, thus leaving the Operator's hands free for greater speed and efficiency.

SOLUTION: Two Model CV-3T cam valves mounted as shown above.

This rugged, non-corrosive, low-cost Airmatic Valve has only one internal moving part and a direct contact roller. Poppets, exposed levers and other actuating means are eliminated. Its compact design and easy operation are particularly desirable to the design engineer for use with air, oil or water, 0-200 psi.

OTHER APPLICATIONS: The Model CV-3T is also superbly suited for vacuum service, reciprocating type of machine tables, grease lubrication control and process systems.

OTHER MODELS: Airmatic makes over 300 models of valves and cylinders for almost every mechanical control need. For complete details, write or telephone Cleveland: WOodbine 1-5320.

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TEFLON SEAL
Saves hours in piping installations
PAT. PENDING
Eliminates leaks in oil, air, water, vacuum, chemical lines
Tru-Seal saves hours in assembling piping installations because it enables you to run your pipe lines in any direction you wish, quickly and easily—without having to recut and re-thread piping sections. Wherever used on air, oil, water, steam, vacuum or chemical lines, it seals perfectly at —100° F. to plus 500° F.—without the use of pipe dope. Its installation requires only light tightening torque, thus eliminating over-tightening damage to valves, pumps, compressors, and other fittings.
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2006 N. Hawthorne Melrose Park, Ill.
"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.
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Thread Tru-Seal on pipe or fitting as far as it will go hand tight.
SEAL SIDE
2
Thread pipe or fitting 3 threads into port. Point in desired direction.
3
Tighten Tru-Seal to complete leakproof assembly (only light torque required).

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ENGINE TURNED PATTERNS
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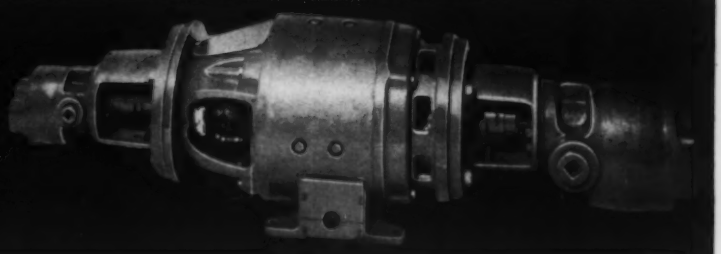
CLOTH TEXTURES
HANDWRITTEN SIGNATURES
CHIPPED STONE SURFACES
Low-cost, one-piece cavities using deliberate undercuts, carefully designed and controlled, often allow two or three times the depth of design normally obtainable.
No hobbing limitations . . . ANY type master may be used, metal, plaster, leather, etc.
Send for our literature and samples.
ELECTROMOLD Corp.
146 Enterprise Avenue
Trenton, N. J.

Circle 590 on Page 19

Circle 588 on Page 19

How stock pumps solve special problems



CASE HISTORY NO. F3954.

The photograph above illustrates Brown & Sharpe's solution of a turbine manufacturer's design problem. The heat absorbed by the turbine during normal operation makes necessary a cooling-off period of about 72 hours prior to inspection or repair of the rotor. To prevent bearing seizure and excessive shaft deflection during this period, the rotor must be turned slowly and the bearings cooled. Brown & Sharpe designed one economical, compact unit to do both jobs: two stock pumps were combined with a special motor to drive them both, one turning the rotor at 1 revolution per hour and the other providing cooling oil to the bearings.

Brown & Sharpe's complete line of gear, vane and centrifugal pumps — backed up by an engineering staff with the experience and knowledge to provide expert advice — has enabled our customers to realize substantial savings in thousands of applications.

For information about B&S pumps for fluid transfer please write to Brown & Sharpe Mfg. Co., Providence, R. I.

For information about pumps and valves for hydraulic applications, write to Double A Products Company, a subsidiary of Brown & Sharpe, Manchester, Mich.

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Circle 591 on Page 19

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A Drafting Table With New Features!

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Sheboygan, Wisconsin

MAYLINE MAYLINE MAYLINE

Circle 592 on Page 19

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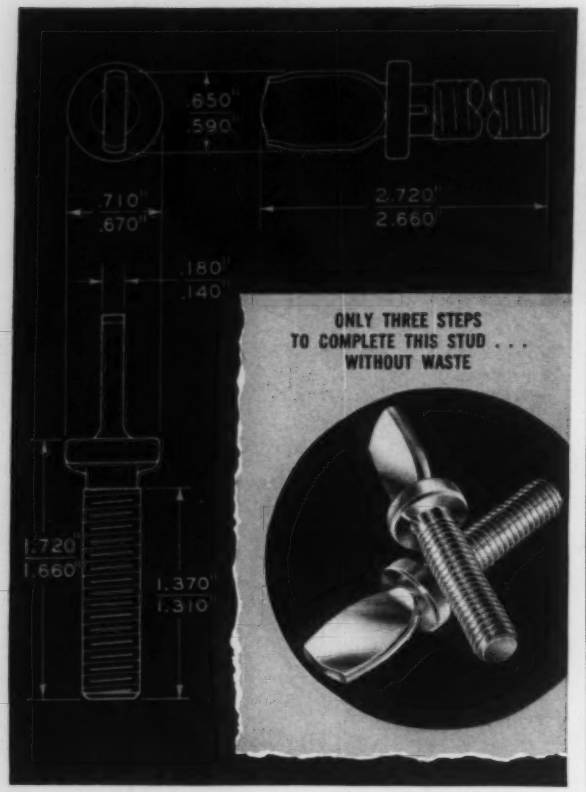

3½ times as many studs
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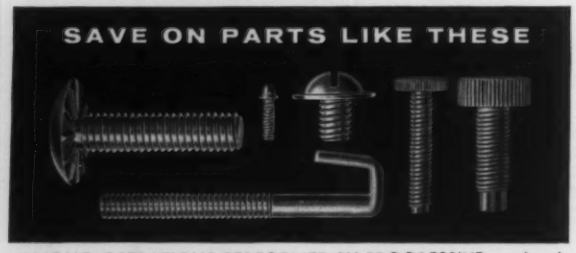

AMONG OPERATIONS PERFORMED BY PROGRESSIVE are heading and extruding simultaneously; flattening; piercing; drilling; bending; pointing; fluted or diamond knurling; trimming; turning tenons, shoulders or recesses; struck or sawed slotting; notching.

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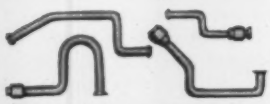

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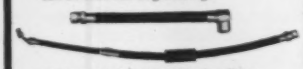

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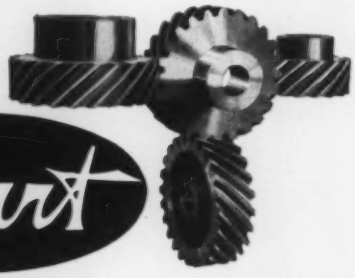

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ABART GEAR and MACHINE CO.
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trimming costs

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COMPACTED METALS CORPORATION
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Circle 597 on Page 19

NEW MINIATURE AGASTAT® time delay relay

for missile, aircraft and electronic applications

INSTANTANEOUS RECYCLING . . . reset time—less than .020 seconds
UNAFFECTED BY VOLTAGE VARIATIONS . . . time delay remains constant from 18 to 30 volts DC
ADJUSTABLE . . . time delays from .030 to 120 seconds
CHOICE OF OPERATION . . . for either energizing or de-energizing
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LIGHT . . . maximum weight—15 ounces
MEETS ENVIRONMENTAL REQUIREMENTS OF MIL-E-5272A

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For specific information on the new AGASTAT relay for your application, write to Dept A30-628.

AGA **ELASTIC STOP NUT CORPORATION OF AMERICA**
1027 Newark Avenue, Elizabeth, New Jersey
Pioneers in pneumatic timing

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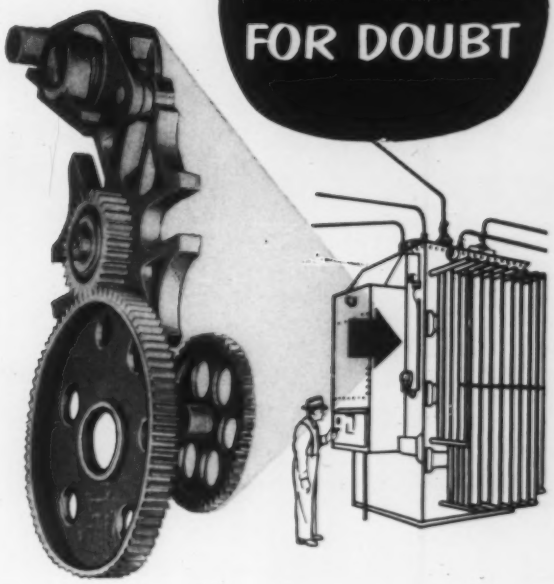
NO ROOM FOR DOUBT



Gears in this Geneva gear drive have to be rugged! They change taps to correct voltage in General Electric high capacity step voltage regulators, where failure could affect the performance of millions of dollars worth of electrical equipment in homes and plants.

Yet, specifications called for thin wall sections and fine tolerances.

Atlantic Casting engineers, working with the engineering department of the General Electric Company, produced gears and drivers to specifications, and all Atlantic-cast components were tested through millions of split-second tap changing operations.

Results of tests? NOT ONE FAILURE!

Atlantic Casting proved itself again, and Atlantic-Cast gears and drivers are now used by the General Electric Company in step voltage regulators of up to 69,000 volts capacity.

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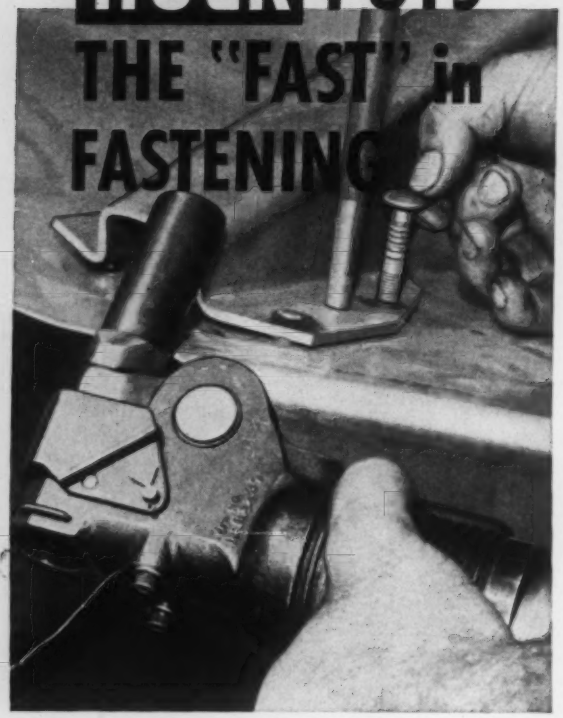
HUCK PUTS THE "FAST" in FASTENING



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Nowhere can you find so many desirable features as you'll get with HUCK FASTeners.

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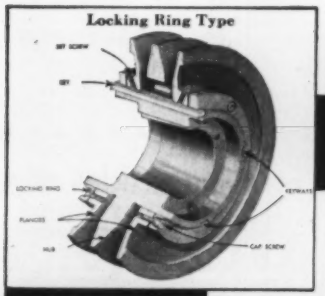

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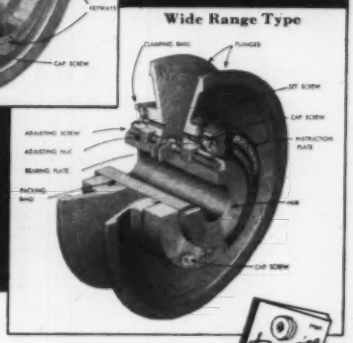
Browning



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Browning POWER TRANSMISSION EQUIPMENT

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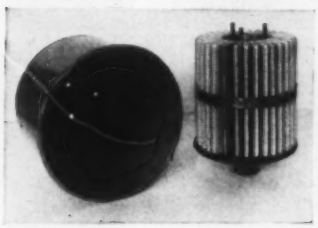

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Circle 604 on Page 19

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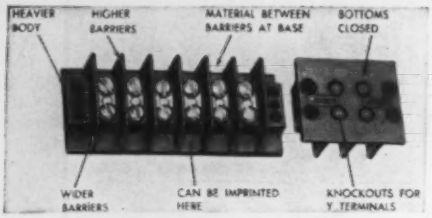

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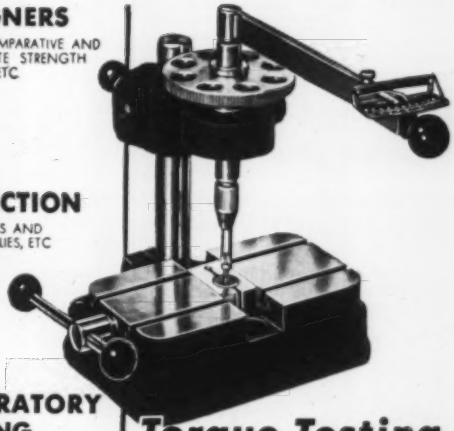
for DELICATE OPERATIONS, ASSEMBLY OF FRAGILE MECHANISMS OR INSTRUMENTS; FOR FASTENERS IN PLASTICS AND LIGHT METALS.



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P.A. STURTEVANT CO.
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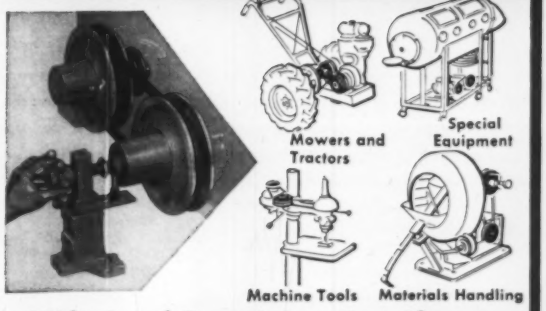
VARIABLE PITCH SHEAVES

Control Speeds on Variety of Machines



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ATLANTIC METAL HOSE

Atlantic flexible metal hose is JOB TESTED & CERTIFIED to withstand the most extreme conditions of temperature, pressure and rough usage. Wall thickness is absolutely uniform. Atlantic hose cannot kink, deteriorate or burst — and requires no maintenance.

Available in steel, bronze, monel and various alloys of stainless steel with proper fittings.

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ATLANTIC METAL HOSE CO. INC.
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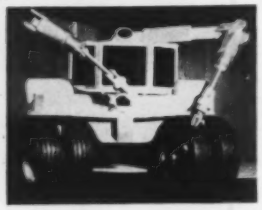
EXPERIENCED IN THE NEW ENGINEERING SPECIALTY

"Remote Handling Equipment"

AN ENGINEER who has significant experience in machine and tool design for remote handling equipment will find a position with high professional potential at General Electric.

This company has already gone a long way in the planning of such manned self-propelled equipment as the "Beetle" whose model is pictured here. "Beetle" will service the nuclear power plants for aircraft which General Electric plays a leading role in developing. It will have a 16 foot reach via manipulators attached to a cab which can be elevated 15 feet or rotated in a complete circle; and will be used at the AEC's National Reactor Testing Station in Idaho.



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Comprehensive benefits • Relocation expenses paid • Graduate study encouraged on full tuition refund basis • Publication of technical papers encouraged

Please write in confidence, including salary requirements, to:
Mr. P. W. Christos, Div. 62-BW
Aircraft Nuclear Propulsion Department
General Electric Company
P.O. Box 132, Cincinnati 15, Ohio

AIRCRAFT NUCLEAR PROPULSION DEPT.

GENERAL ELECTRIC

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ENGINEERS

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AVAILABLE: Senior Mechanical Design Engineer for board work. High grade draftsmanship on assemblies. Superior ability on design of machinery, product, power press dies, production tools. Originality and ingenuity on new developments. Any location and length of engagement. Address: Boxholder, 202 Back Bay Postal Annex, Boston, Massachusetts.

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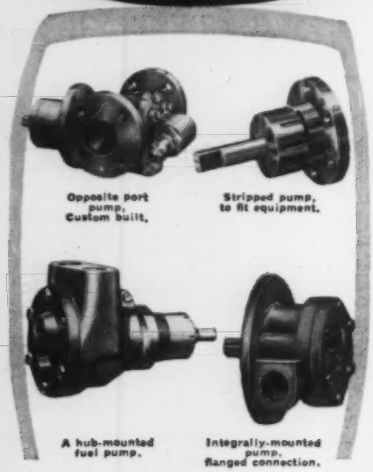
BPA NEP

on Your Equipment

VIKING PUMPS ADD BUILT-IN QUALITY


Opposite port pump. Custom built.
Stripped pump, to fit equipment.
A hub-mounted fuel pump.
Integrally-mounted pump, flanged connection.

If you are a manufacturer of machines requiring pumps, it will pay you to learn how a Viking rotary pump could add quality, as an integral part of your equipment. The standardization of Viking Pumps on so many pieces of equipment in the industrial field proves their successful performance.

so, if you manufacture . . .

- Diesel engines
- Paint application equipment
- Transport trucks
- Spraying equipment
- Ice machines
- Food and chemical processing equipment
- Oil heaters
- Feed mixers
- Marine gear sets
- Dry cleaning equipment
- Milk trucks
- Speed recording equipment
- Asphalt distributors
- Hydraulic lifts
- Oil well fracturing equipment
- Ammonia systems
- Industrial burners
- Pipe line coating equipment
- LP-Gas fuelers
- Fuel delivery trucks and many others . . .

. . . ask Viking to show you a pump that will help build quality into your equipment. To start, ask for folder 409H today!

VIKING — the leader, not a follower, in Rotary Pumps

VIKING Pump Company
Cedar Falls, Iowa
In Canada, it's "ROTO-KING" pumps

See Our Catalog in Sweet's Product Design File

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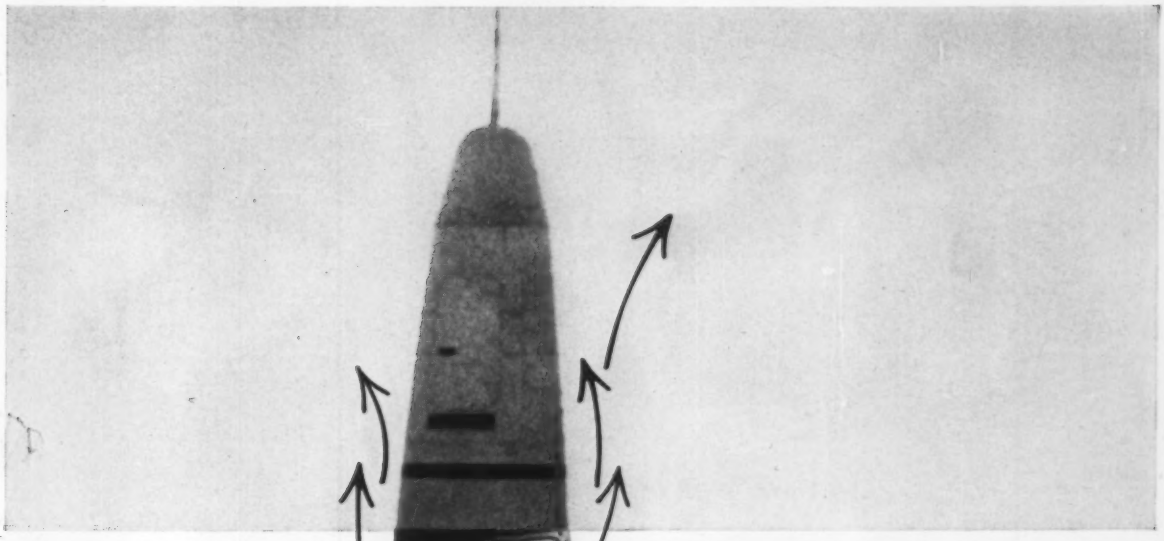

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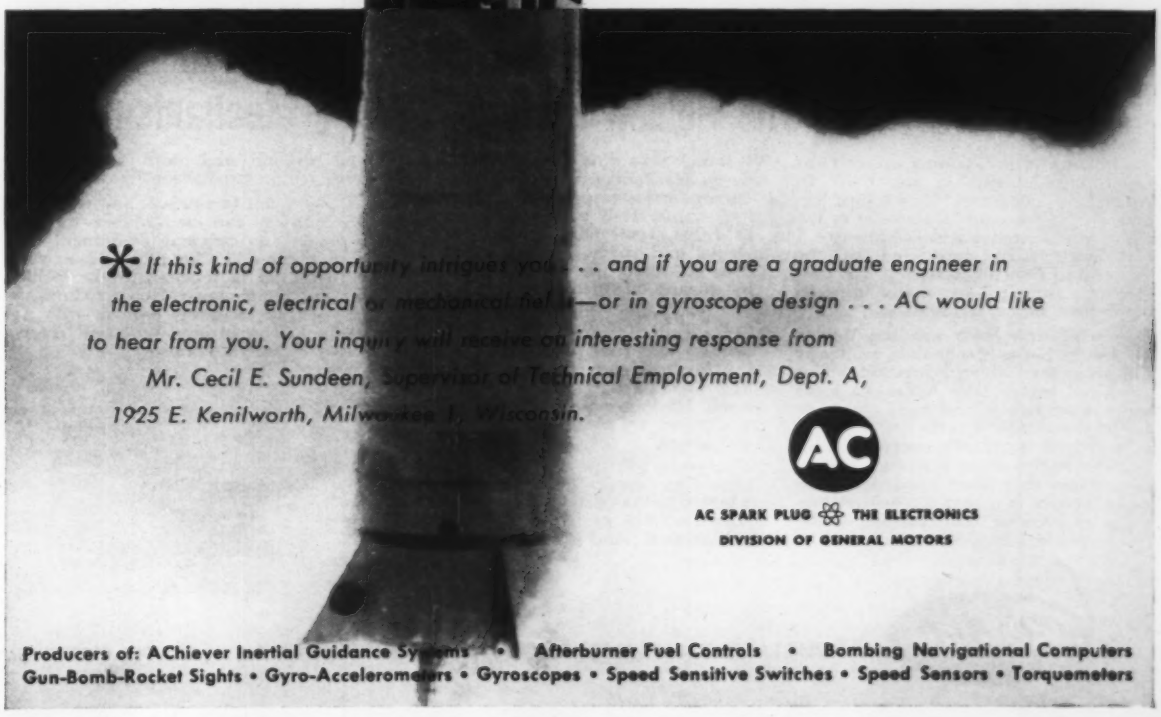
Why not go up and grow up . . . with AC and with missiles? You can work* with a team of engineering experts on AC's vital and far-reaching guidance systems. Or, you can exercise your talents on the development and production of many other electronic projects that make AC a new leader in the industry. What's more, you'll enjoy the stability and security and benefits that General Motors offers all their personnel.



** If this kind of opportunity intrigues you . . . and if you are a graduate engineer in the electronic, electrical or mechanical field—or in gyroscope design . . . AC would like to hear from you. Your inquiry will receive an interesting response from Mr. Cecil E. Sundeen, Supervisor of Technical Employment, Dept. A, 1925 E. Kenilworth, Milwaukee 1, Wisconsin.*

AC

AC SPARK PLUG ⚛ THE ELECTRONICS DIVISION OF GENERAL MOTORS

Producers of: AChiever Inertial Guidance Systems • Afterburner Fuel Controls • Bombing Navigational Computers Gun-Bomb-Rocket Sights • Gyro-Accelerometers • Gyroscopes • Speed Sensitive Switches • Speed Sensors • Torquemeters

Alex Dreier and Walt Behlen, President of Behlen Manufacturing Company, demonstrate the Behlen Powr-Steer to engineers attending the 1958 Design Engineering Show. It is mounted anywhere along the steering shaft and has both right hand and left hand operation. Dimensions: 15½"x4½"x6-9/16".

ALEX DREIER, NBC's "Man On The Go" Reports On The Behlen Hydraulic Servo Mechanism

Part of my job is keeping up with unusual developments in any field. In April I attended the 1958 Design Engineering Show and Conference at the Chicago International Amphitheatre. I was particularly interested in the Power and Control section of this conference, attended by many original equipment manufacturers.

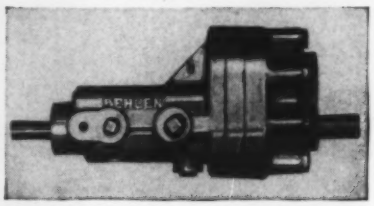
On exhibition here was the Behlen Hydraulic Servo Mechanism, originally known as the Behlen Powr-Steer. This advanced rotary type hydraulic servo mechanism has proved highly successful on thousands of farm tractors. It is a gear-type hydraulic mechanism in contrast to the piston type used on passenger cars and other equipment. The power source is a gear motor that provides continuous 360° turning under full power in either direction.

I found that *this Behlen Hydraulic Servo Mechanism* is capable of almost instantaneous response to the controlling signal. It is actuated by as little as 1 lb. of mechanical force. It also blocks and controls wheel shocks. It does not affect the steering ratio. And by means of mechanical linkage it maintains full and positive control in event of hydraulic power failure.

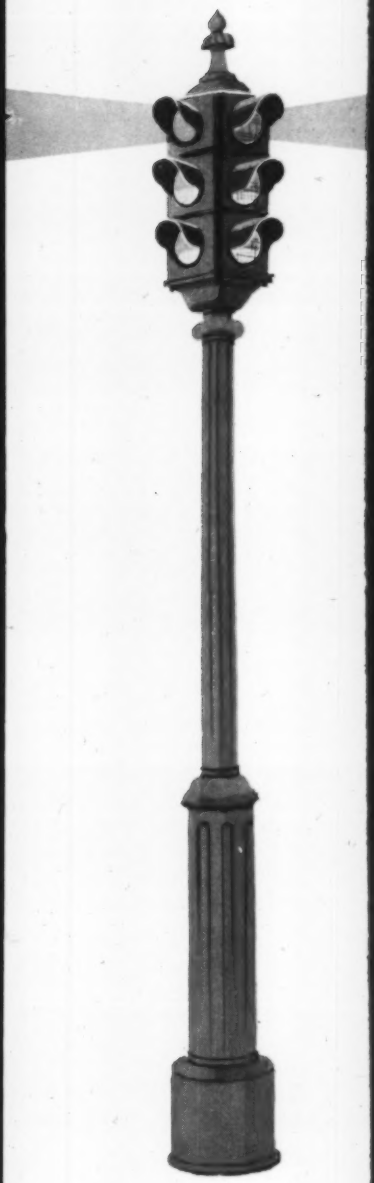
Behlen was first to offer power steering for row crop tractors, five years ago. For the past two years International Harvester has used it as original equipment on their Farmall 300 and 400 series.

Engineers tell me *the Behlen unit's versatility* suggests it can be easily adapted to many industrial, heavy construction and agricultural equipment applications. And it can be done without drastic and costly engineering changes on production lines.

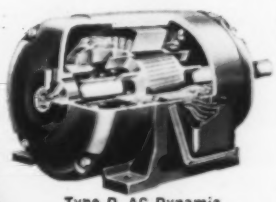
If you want to see just how easily the mechanism can be applied to your products as original equipment and how it can add a big plus to their sales appeal, get in touch with the Behlen production manager, Howard Christensen. Your request (which will not obligate you in any way) will receive his personal attention.



Behlen **Manufacturing Company** Dept. DM-6, Columbus, Nebraska



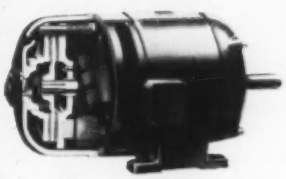
GIVE YOUR PRODUCTS THE BEST OF BRAKES!



Type D, AC Dynamic

ROLLING STOP... Master Type D Dynamic Unibrake Motors. Braking is obtained with a unique, patented brake winding superimposed on the stator winding. Simple, compact, with no DC current required, the brake has no moving parts. There is nothing to wear or adjust... braking torque repeats consistently. Particularly recommended for automatic applications where static holding is not desired. Sizes ¼ to 30 H.P.

MASTER UNIBRAKE MOTORS



Type M—Magnetic

STOP-HOLD... Master Type M Magnetic Unibrake Motors. For quick, controlled stopping... especially when you want to hold the load. Spring-setting magnetic brakes of the friction disc type combine with motor in a compact, integral unit. Sizes... ⅛ to 150 H.P.

MASTER GEARMOTORS and variable speed drives can be furnished with Unibrakes, too. See Master for the perfect power drive for you.

THE MASTER ELECTRIC CO.

DAYTON 1, OHIO

DIVISION OF RELIANCE ELECTRIC AND ENGINEERING CO.

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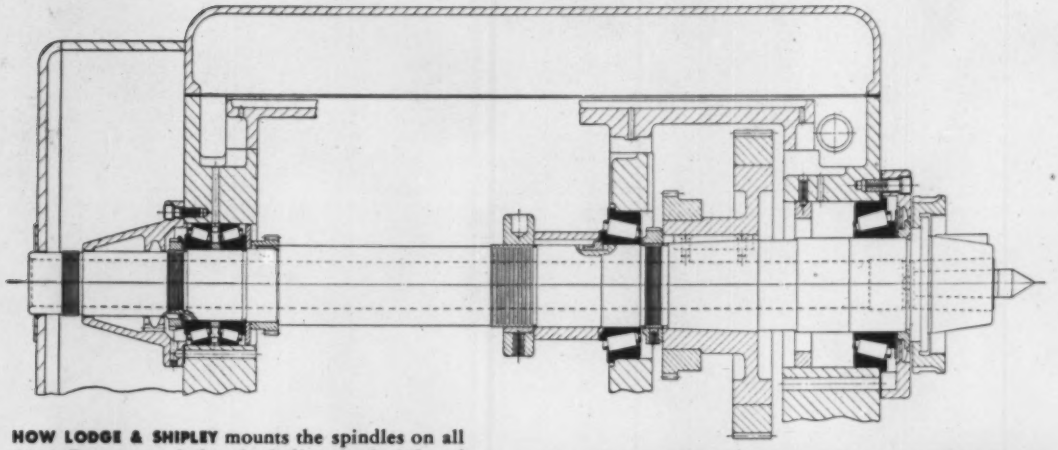
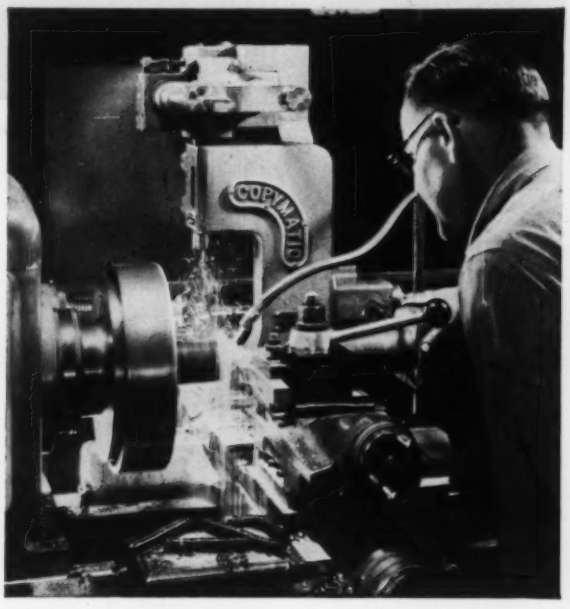


HOW LODGE & SHIPLEY mounts the spindles on all 2013 Powerturn lathes including both 45° and 90° Copymatics on Timken bearings to get extra rigidity, maintain accuracy, reduce maintenance.



New type lathe ups production 200%, saves users an estimated $8,000 a year

...one secret—TIMKEN® bearings on the spindle

"Production increases as high as 200%"..."Overall savings estimated at $8,000 a year"—read user reports about the new 2013 Powerturn 90° Copymatic Lathe. One important reason for such exceptional results is that Lodge & Shipley mounts the spindle on Timken® tapered roller bearings. Timken bearings give it the vital extra rigidity and hold runout to the minimum needed for tracer accuracy.

How spindle is held rigid. Timken bearings hold the spindle in positive alignment. They take *both* radial and thrust loads in any combination, because of their tapered design. And because of full line contact between rollers and races, Timken bearings have extra load-carrying capacity.

Why heavy shocks are absorbed. Case-carburization of Timken bearings' rollers and races gives them hard, wear-resistant surfaces and tough, shock-resistant cores.

How friction is virtually eliminated. Timken bearings are geometrically designed to roll true. And they're precision-made to live up to their design. They run smoother—last longer.

We even make our own electric furnace fine alloy steel, for extra quality control. We're America's only bearing maker that does. To get all these advantages, always specify bearings trade-marked "TIMKEN". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN *TAPERED ROLLER BEARINGS ROLL THE LOAD*

TRADE-MARK REG. U. S. PAT. OFF.

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